APPENDIX J

Restoration Plan

FREDERICK COUNTY STORMWATER RESTORATION PLAN

DECEMBER 2019

Contents

Tables

Figures

ACKNOWLEDGEMENTS

This Plan is a product of several decades of cumulative planning and restoration efforts on the part of Frederick County Government staff, community partners, and consultants. The Plan is also a collaborative project between Staff, consultants, and subject matter experts.

Rhonda Hughes, from KCI Technologies, Inc, worked with Jeremy Joiner and Donald Dorsey, Frederick County, to update the geodatabase of completed, programmed, and identified stormwater projects and summarize progress by BMP type, status, and date to meet several specific needs for TMDL and impervious area restoration plans.

Rhonda also ran the geodatabase modeling tool used for nutrient and sediment modeling, assisted by Maria Pittman.

Bill Frost, Danielle DePalo, and Olivia Devereux rewrote the Watershed Treatment Model (WTM) specifically for bacteria to simplify data entry and modeling for five scenarios. Bill Frost subsequently calibrated the new spreadsheet model and completed the modeling for this plan. Bill also managed and updated the projects, text, tables, and figures from the previous Restoration Plan for this report.

Project oversight, guidance, and reviews were provided by Don Dorsey and Shannon Moore of Frederick County OSER. Shannon Moore wrote the original version of this plan that also serves as the template for this document.

ACRONYMS AND ABBREVIATIONS

BMP: Best Management Practice
BRF: Chesapeake Bay Restoration Fund
CAA: Clean Air Act
CFR: Code of the Federal Register
CFU: Colony Forming Units
CBP: Chesapeake Bay Program
CBWM: Chesapeake Bay Watershed Model
CWA: Clean Water Act
E.coli: Escheria coli
FIB: Fecal Indicator Bacteria
FY: Fiscal Year
MDE: Maryland Department of the Environment
MEP: Maximum Extent Practicable
MFSG: Municipal and Financial Services Group
MPN: Most Probable Number
MPR: Maximum Practicable Reduction
MS4: Municipal Separate Storm Sewer System
NPDES: National Pollutant Discharge Elimination System
OSER: Office of Sustainability and Environmental Resources
P3: Public-Private Partnership
Plan: Frederick County Stormwater Restoration Plan. Includes Impervious Cover Restoration Plan, 12 local TMDL and 2 Chesapeake Bay TMDL Restoration Plans.
RR: Runoff Reduction
SSO: Sanitary Sewer Overflow
ST: Stormwater Treatment
Stormwater Accounting Guidance: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* document by MDE
TMDL: Total Maximum Daily Load
WIP: Watershed Implementation Plan
WTM: Watershed Treatment Model
WWTP: Wastewater Treatment Plant

EXECUTIVE SUMMARY

This update to the Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and an impervious surface restoration requirement. This Plan demonstrates that Frederick County Government is on track to meet the restoration efforts required under its current permit and has a long-term plan to address its portion of stormwater wasteload allocations for all TMDLs in Frederick County. The 2016 Restoration Plan was posted to the website on May 30, 2016. Public notice was published in the Frederick News Post on May 31 and June 1. The thirty day review period went from May 31 to June 30. The 2016 Restoration Plan was submitted to MDE on June 30, 2016. All yearly updates to the Restoration Plan are made available to the public on the County's website.

Compliance with the Chesapeake Bay TMDL is regulated in the permit through the use of the 20% impervious surface treatment strategy. While not a requirement in the County's MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress in reducing pollutant loads. These results were provided for information purposes only.

All Restoration Plans use a multi-pronged approach that includes stormwater practices. These stormwater practices include volumetric practices such as bioretention and pond retrofits, as well as alternative practices for stormwater including riparian buffer planting and stream restoration. Best Management Practices (BMPs) used are predominantly from MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE SW 2014). This document determines how impervious acres are accounted for. To assess whether nutrient and sediment local TMDL goals were met, these practices were modeled using a customized script in ArcGIS which calculated pollutant load reductions treatment based on the inventory of existing, programmed, and identified BMPs maintained in the County's NPDES geodatabase. The same tool was used to estimate load reductions applied towards the Chesapeake Bay TMDL. Progress towards *E. coli* TMDL loads and reductions were determined using the Watershed Treatment Model version 2013. Structural stormwater treatment was summarized from the County database, supplemented with literature values and Sanitary Sewer Overflow (SSO) loads and reductions calculated by the Division of Utilities and Solid Waste Management for secondary sources of bacteria.

The individual plans in this document are organized by Restoration Tier. Restoration Tiers include Baseline, Completed, Programmed, Identified, and Potential scenarios:

- Baselines are the TMDL loads without restoration BMPs.
- Completed projects were finished after March 11, 2007, the expiration date of the previous permit and before June 30, 2019, the reporting date for the current Annual Report.
- Programmed projects are entered into the County's Capital Improvement Program and other programs. They have funding and schedules. As subsets of Programmed Projects are to be completed during the permit term, which is set to expire December 29, 2019. This subset is in the Impervious Cover Restoration Plan. All Programmed projects are expected complete by 6/30/2023.
- Identified projects can be found in Watershed Assessment Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government, its partners, and consultants to identify watershed restoration opportunities. They may be included within funds for an existing CIP but are not yet labeled as projects. They are expected complete by 6/30/2025.

- Potential Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land. They are expected complete by 6/30/2052.

Frederick County submitted an Impervious Surface Area Assessment of its MS4 Discharge permit with its first Annual Report under the new permit (Frederick County, 2015).

- The baseline in the previous permit was derived using the Simple Method (Schueler, 1987); which applied impervious cover coefficients to land use/land cover (LU/LC) maps from Maryland Department of Planning. This method has been replaced by the use of planimetric data, where actual impervious areas are digitized from aerial survey.
- Frederick County submitted its Fiscal Year 2018 Annual Report in December 2018 as its fourth annual report submission for this permit term. At the MDE's request Frederick County included in this report submission a revised impervious surface cover assessment. MDE provided comments on this annual report submission on July 12, 2019. In its comments, MDE states that it cannot approve the County's revised impervious cover assessment because the County's baseline update did not have adequate documentation to definitively identify the impervious acreages treated by various BMPs in the County's rooftop and non-rooftop disconnect analyses.
- Frederick County notes that the revisions to the rooftop and non-rooftop analyses included in the County's impervious cover resubmission, and reported in the 2018 Annual Report Appendix O: Impervious Accounting Memo and geodatabase, were conducted in the expanded MS4 Boundary. However, the update to the Boundary area was not provided for in Appendices P and Q, Rooftop Disconnect Protocol and Non-Rooftop Disconnect Protocol. Essentially, the revised impervious cover assessment was conducted correctly, but the protocol document language detailing the new extent was not updated when submitted with the 2018 Annual Report.
- MDE noted in its August 23, 2019 memo, which tentatively approved the County's Financial Assurance Plan, that approval of the impervious area analysis was still pending. The County updated the impervious cover restoration plan as well as two technical memos for rooftop and non-rooftop disconnect studies, and submitted them to MDE on September 30, 2019. Frederick County staff met with MDE on October 24th where it was decided by MDE that the impervious cover analysis was pending approval of the non-rooftop disconnect study. A field visit was planned to review the study findings with MDE; however, McCormick Taylor in reviewing for the field meeting discovered a significant error in its work for the rooftop and non-rooftop studies. They had used the wrong projection file that caused the county's restoration obligation to be underestimated by 711 acres. Again, the impervious cover assessment was conducted using the correct boundary and by the correct protocol but with an error in the projection which caused the discrepancy. The County has been working to review the work with the consultants as well as any impacts this error may have created with other studies, and to redouble efforts to look for baseline reduction credits in MDE-approved protocols.
- Apart from the rooftop and non-rooftop disconnection issue, MDE does not appear to take issue with the County's methodology for the revised submission or its results, which is the same MDE-approved methodology MDE used with substantially similar results. In some instances, Frederick County had access to better source data, which resulted in slightly different numbers than what MDE calculated from its analysis; the small differences are outlined in the methodologies section. Frederick County respectfully submits additional clarity in how it developed its impervious baseline by adhering to the methods outlined by Maryland Department of the Environment (MDE).

Based on the analysis provided in this memo and in the Appendices, Frederick County used MDE's guidance and comments to determine there are 13,396 total impervious acres within its boundary, of which 678 acres are treated with BMPs, 403 impervious acres are treated through rooftop disconnect, 2,259 impervious acres are treated through non-rooftop disconnect, 51 acres are treated through existing grass swales, 64 acres are treated by draining to Maryland State Highway Administration BMPs from the Frederick County MS4 area, and 38 acres are treated through sheetflow to conservation areas. This leaves the County with 9,903 untreated impervious acres. Based on the 20% restoration requirement, Frederick County will need to treat 1,981 impervious acres to meet its MS4 Permit Restoration requirement.

The County has once again rerun its impervious cover assessment to correct for the problems created by McCormick Taylor's error. The results of that analysis are summarized as follows, and the memo containing the detailed analysis is included in the 2019 Annual Report Submission.

Table 1: Frederick County Impervious Accounting (as of 12/23/2019)

Impervious Accounting Areas	Area (ac)
Total Impervious area within MS4 Permit Area	13,396
Treated Impervious	(-678)
Rooftop Disconnect	(-403)
Non Rooftop Disconnect	(-2,259)
Existing Grass Swales Districts 3-6	(-51)
SHA Treated County Impervious	(-64)
Sheetflow to Conservation Area	(-38)
Untreated Baseline	9,903
Restoration Goal	**1,981**
Completed as of 6/30/2019	**749**
Programmed (subset to be completed by 12/31/2019)	**658**
Nutrient Trading	**574**
Total Restored	**1,981**

- Using MDE's MS4 boundary definition, the County has 13,396 acres estimated in its untreated impervious cover baseline. The Impervious Cover Restoration Plan in this document plans for the permit requirement to restore 20% of this untreated urban impervious area. Table 1 shows the current figures on baseline untreated area, restoration from projects and programs established prior to the baseline, and a calculation of the impervious restoration requirement.

MDE's regulations for the Maryland Water Quality trading Program became effective on July 16, 2018. MDE updated its Draft Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed (MDE 2017) in April 2017. Trading requirements for MS4 communities are also lain out in MDE SW 2014. Frederick County's MS4 permit went through a major modification in order to use trading. This modification was final on November 8, 2019. Based on FY19 restoration credit estimates, the County plans to use MDE's trading program to generate 574 acres of credits from its wastewater treatment plant at Ballenger McKinney. This plant's permit was recently reissued and includes trading. The County modified its permit with MDE upon reissuance to include the option to generate credits.

Table 2: Credits available from Ballenger-McKinney WWTP

Performance Based EOS Load (from DMR)	Generated Credits

	Pounds (Current)	Pounds (Year End Estimate)	Tons	EOT Factor	MDE Reservation	lbs	tons
N	29,665	39,554		0.59	0.95	22,170	
P	4,161	5,548		0.47	0.95	2,477	
Sediment	220,823	294,431	147	0.65	0.95		91

- It is anticipated that the Ballenger-McKinney WWTP will have more than adequate credits for Nitrogen and Phosphorus. Should additional sediment credit be needed, the County plans to use a substitution method used by Anne Arundel in its trading proposal, purchase sediment credits from another plant, and/or generate additional sediment from tree plantings and stream restoration.

Restoration numbers will necessarily adjust due to implementation schedules for future projects and other unforeseen issues; future versions of the plan will reflect any needed changes.

The twelve local TMDLs addressed in this document are shown in Table 3 and Figure 1 below. The TMDLs address impairments from phosphorus, sediment and *E. coli*. Each TMDL's SW-WLA for Frederick County Government's MS4 has its own TMDL Restoration Plan within this Stormwater Restoration Plan.

Table 3: Local TMDL Pollutant Load Percent Reductions by Watershed

Watershed	MDE Published Reduction	Bacteria Reduction Human / Domestic	County Planned Reduction	% of Goal Achieved	Completion Date
Catoctin Creek TP	11.0%		23.5%	213.5%	2027
Catoctin Creek TSS	49.1%		49.2%	100.1%	2033
Double Pipe Creek EC	98.8%	56.3%	57.2%	101.6%	2028
Double Pipe Creek TP	73.0%		76.1%	104.3%	2025
Double Pipe Creek TSS	46.8%		209.9%	448.6%	2023
Lower Monocacy River EC	92.5%	45.3%	45.6%	101.6%	2048
Lower Monocacy River TP	28.0%		28.0%	100.0%	2052
Lower Monocacy River TSS	60.8%		88.6%	145.7%	2042
Potomac River Montgomery Co. TSS[1]	36.2%		--	--	--
Upper Monocacy River EC	97.0%	48.5%	49.8%	102.7%	2030
Upper Monocacy River TP	4.0%		16.1%	401.8%	2024
Upper Monocacy River TSS	49.0%		49.0%	100.1%	2033

(1) MDP Land use shows no urban area in County portion of this watershed. Baseline load modeling will be re-evaluated using Phase 6 CBWM in the future

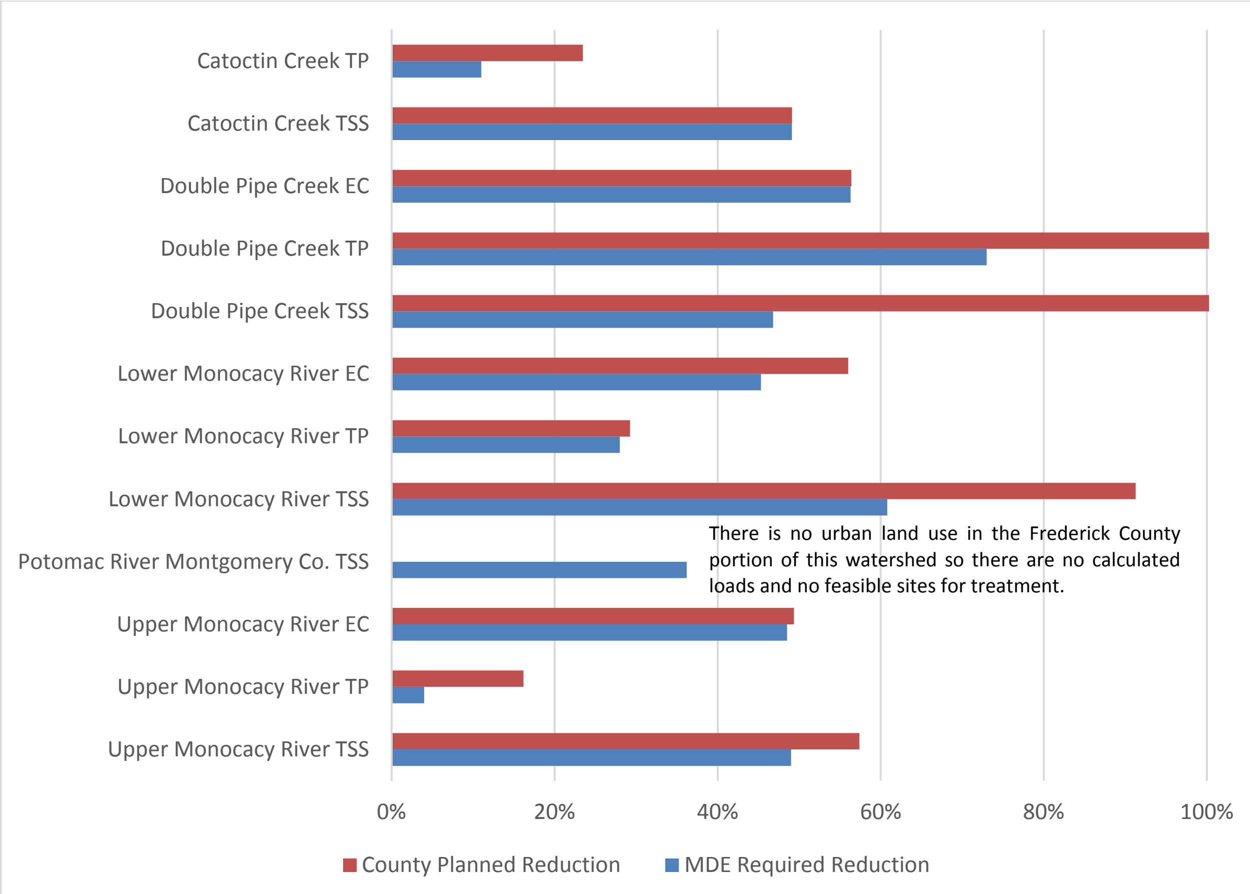


Figure 1: TMDL Pollutant Load Percent Reduction

This Frederick County Stormwater Restoration Plan continues to satisfy the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. The Plan will take a cumulative 33 years from the date of the report to address TMDL requirements, and will cost a cumulative amount of $179,389,137. (Table 4). The Restoration Plan also meets TMDL pollutant removal targets for all 12 local TMDLs, as shown in Table 3. Pollutant reductions for the Chesapeake Bay TMDL have been compared with MDE's suggested targets. The projects and programs proposed in this plan will provide 239% of the amount of phosphorus targeted and 72% for nitrogen in the Phase II WIP for the Chesapeake Bay. The Phase III WIP was issued after July 1, 2019 and will be included in the next update to this document. It is largely programmatic at the County level for stormwater.

Table 4: TMDL Restoration Timeline and Cost Estimate

Scenario	Begin Date	Complete Date	Duration (Years)	Cost
Completed	3/11/2007	6/30/2019	12.3	$5,878,512
Programmed	7/1/2019	6/30/2023	4.0	$38,316,922
Identified	7/1/2019	6/30/2025	6.0	$14,316,994
Potential	7/1/2025	6/30/2052	27.0	$120,876,709
Total from Report Date[1]			**33.0**	**$179,389,137**
[1] Duration from Report (7/1/2019) to end of **Potential** tier (6/30/2052)				

This document relies on currently accepted practices to meet the pollutant and impervious cover restoration requirements that are required by the MS4 permit and the Stormwater Accounting Guidance; however, it is clear that additional alternatives and efficiencies could be considered in the future in order to address the TMDL. The question should be asked: what is the most cost-effective way to reduce the pollutants in the local and Bay TMDLs? The answer to that will likely include a number of key concepts:

1. Reduction of atmospheric deposition of nitrogen: the Chesapeake Bay TMDL 2010 baselines from EPA included atmospheric deposition reductions from nitrogen due to portions of the Clean Air Act that were implemented. Future actions, such as the low sulfur fuels standard, were not included. Future versions of EPA allocations will likely show additional reductions from expanded implementation of the CAA and other air rules.

   Maryland applied NOx reductions from its own Clean Cars Act and Healthy Air Act to open water, as no BMPs currently exist for this land use; however, if the reductions occur across the land they should be more evenly distributed. There should be a mechanism to allow jurisdictions to count their atmospheric NOx reductions towards the Bay. Consideration should also be given for BMPs that the County implements to reduce atmospheric pollution, such as the conversion of its bus fleet to all-electric.

   Thus far, the County purchased six electric buses and secured funding for an additional three electric buses. Related to that, the County has installed 10 bus charging stations and has provided the infrastructure for an additional 10 charging stations. More charging stations are planned for a future transit facility expansion. The County has also installed five charging stations for its hybrid fleet passenger cars.

   In addition, the County is installing a solar array at the Reichs Ford Road Landfill that will generate enough renewable energy to supply about 20% of the County's general electric usage. The array is expected to produce more than 3 ½ million kilowatt hours of electricity a year. Through a net metering agreement, electricity generated by the solar array is transferred to Potomac Edison's power grid. The County then offsets power costs at designated County facilities, including the bus charging stations.

   On December 19, 2018, County Executive Jan Gardner held a ground-breaking ceremony for a solar PV project. This major sustainability project will involve the construction of a nearly 2 million kilowatt-hour photovoltaic solar array on 4.9 acres of vacant land to provide low-cost renewable energy to the Ballenger-McKinney Waste Water Treatment Plant.

   The State's draft Greenhouse Gas Reduction Act plan has many elements that would reduce NOx and nitrogen deposition to the Bay.

2. Large scale (Baywide or statewide) education and management programs for pet waste and urban fertilization could provide a cost-effective way of reducing pollution that is not clearly addressed in the Stormwater Accounting Guidance.

INTRODUCTION

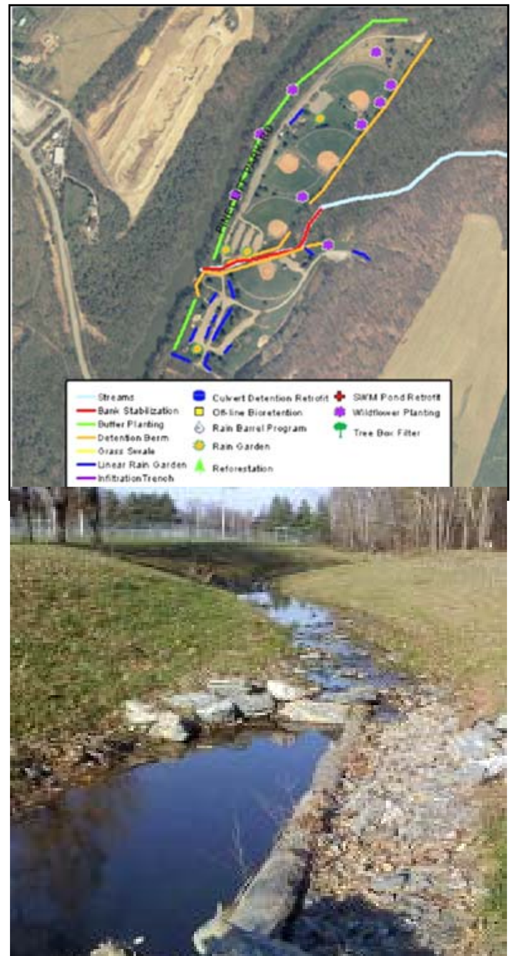
Ballenger Creek Stream Restoration Time Series

PLAN REQUIREMENTS

This Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and a 20% impervious surface restoration requirement. The TMDLs address impairments from nitrogen, phosphorus, sediment and *E. coli*.

This Plan should be viewed as a planning document that is subject to the County's review and revision in future years consistent with adaptive management, which is a cornerstone of any good water quality program. Adaptive management means that the Plan's estimated dates and costs for completion of various projects may change over time, and that projects may be substituted based on lessons learned as implementation progresses.

This plan assumes certain removal efficiencies for BMPs as a part of the development of the plans. For example, better information on BMP effectiveness or new treatment approaches will be considered for future updates of the plan. Finally, the County's ability to implement milestone actions depends on approval and funding from the local governing body in future years.



Pinecliff Park Stream Restoration

IMPERVIOUS COVER RESTORATION PLAN REQUIREMENTS

Part IV.E.2.a of the permit describes the requirement for the Impervious Cover Restoration Plan:

> *"by the end of this permit term, Frederick County shall commence and complete the implementation of restoration efforts for twenty percent of the County's impervious surface area consistent with the methodology described in the MDE document cited in PART IV.E.2.a. that has not already been restored to the MEP. Equivalent acres restored of impervious surfaces, through new retrofits or the retrofit of pre-2002 structural BMPs, shall be based upon the treatment of the WQv criteria and associated list of practices defined in the 2000 Maryland Stormwater Design Manual. For alternate BMPs, the basis for calculation of equivalent impervious acres restored is based upon the pollutant loads from forested cover."*

By December 29, 2019, Frederick County is required to restore 20% of the County's impervious surface within the MS4 that is not treated to the Maximum Extent Practicable (MEP). It must use standards from MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE, 2014).

TOTAL MAXIMUM DAILY LOAD RESTORATION PLAN REQUIREMENTS

Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant, measured in mass per day, which a water body can receive while still meeting state water quality standards and designated uses. TMDLs are comprised of two main elements. The first is a Wasteload Allocation (WLA), which includes point sources with a permitted discharge such as wastewater or that include National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4)-regulated urban stormwater permits. The other component is a Load Allocation (LA), which includes nonpoint sources. Nonpoint source examples include loads from agriculture, forest, and non-regulated urban areas.

As a requirement of PART IV.E.2.b of the Permit, issued by MDE to Frederick County, the County must develop restoration plans for each Stormwater Wasteload Allocation (SW-WLA) approved by the Environmental Protection Agency (EPA) prior to the effective date of the permit. This applies to all current local TMDLs as well as any new TMDLs approved by EPA. There are currently 12 final approved local TMDLs within Frederick County with either an individual or aggregate SW-WLA, shown in the table below. This Restoration Plan identifies management actions and practices that will address the portions of the SW-WLAs attributable to the County's MS4 for these 12 local TMDLs. This Restoration Plan does not account for MDE's Phase III Watershed Implementation Plan (WIP) which was published on August 23, 2019.

Table 5 - Frederick County Local TMDLs with SW-WLAs

Segment	Impairment	Allocation Type	Baseline Year
Catoctin Creek	Phosphorus	Individual	2009
Catoctin Creek	Sediment	Aggregate	2000
Double Pipe Creek	Phosphorus	Individual	2009
Double Pipe Creek	Sediment	Aggregate	2000
Double Pipe Creek	*Escherichia coli*	Aggregate	2004
Lower Monocacy River	Phosphorus	Individual	2009
Lower Monocacy River	Sediment	Aggregate	2000
Lower Monocacy River	*Escherichia coli*	Aggregate	2004
Potomac River Montgomery County	Sediment	Individual	2005
Upper Monocacy River	Phosphorus	Individual	2009
Upper Monocacy River	Sediment	Aggregate	2000
Upper Monocacy River	*Escherichia coli*	Aggregate	2004

The permit language states that the TMDL restoration plans must include:

- "the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs." The final date presented in this document is for the completion of all Potential projects, sufficient to meet pollutant load reductions for all TMDLs.
- "detailed cost estimates for individual projects, programs, controls, and plan implementation". "monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs."
- "Development of "an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments."

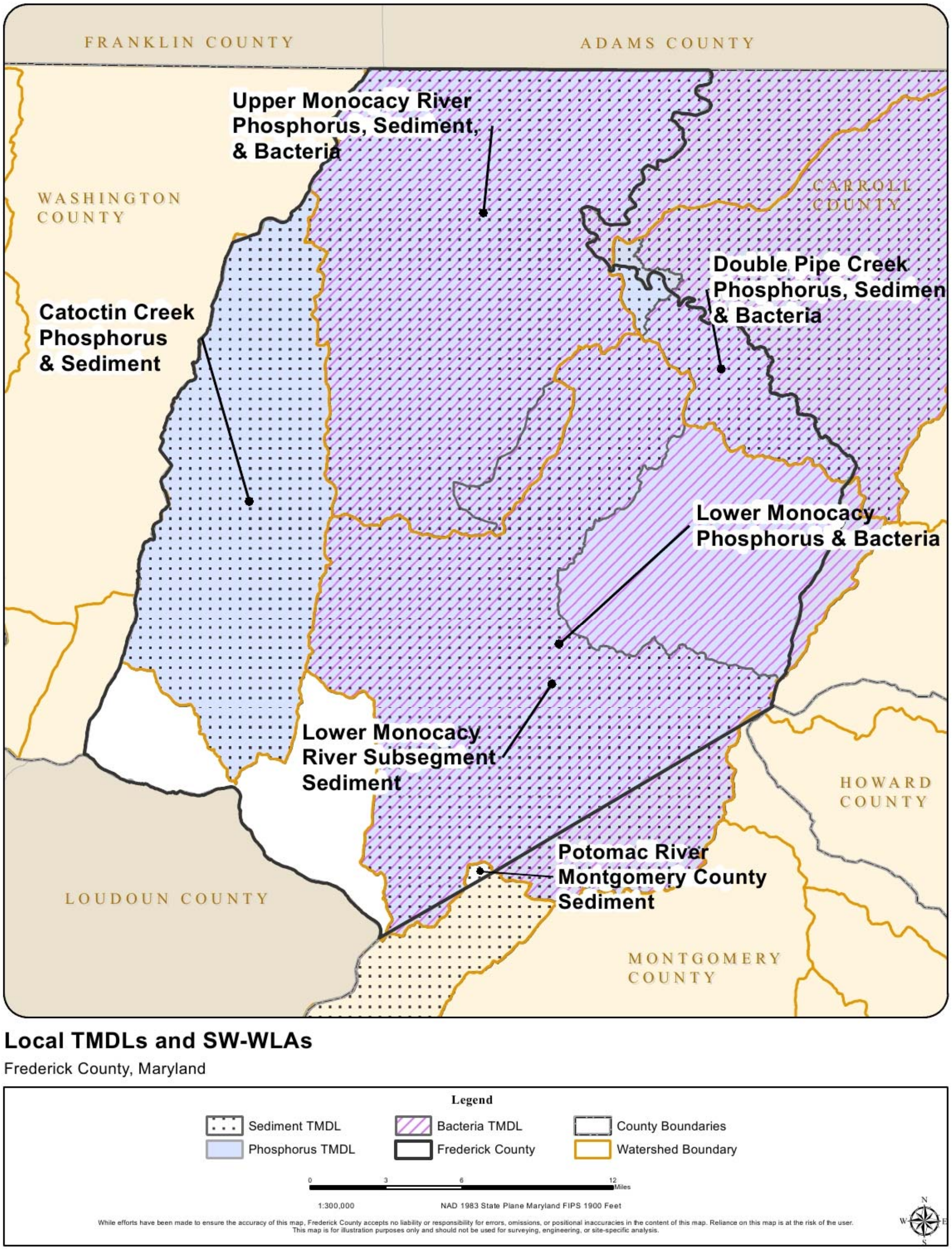


Figure 2: Frederick County Local TMDLs

RESTORATION TIERS

The County developed its Restoration Plan using the following tiers and definitions:

Figure 3: Restoration Tiers

- **Baseline:** reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL or impervious surface goal was established (2000/2005 for sediment TMDLs; 2009 for phosphorus TMDLs; 2010 for nitrogen and phosphorus in the Bay; and 2004 for *E. coli* TMDLs). In the case of the Impervious Cover Restoration Plan, the baseline is the end date of the previous MS4 permit, March 11, 2007. These projects in the Baseline do not count as pollutant reductions in any restoration scenario. Instead they are part of the baseline load.
- **Completed:** These projects apply to restoration. They have been completed between the baseline date and June 30, 2019, the end of the reporting period for this Restoration Plan. The projects have been inspected and verified to ensure that they meet MDE's requirements. A project-by-project list for the **Completed** scenario is included in Appendix 1.
- **Programmed:** These projects are under contract or funded and have a proposed completion date on or after July 1, 2019. A project list for the **Programmed** scenario is included in Appendix 2. Projects are scheduled for completion by 6/30/2023. A subset of Programmed Projects to be completed by December 29, 2019 is in the Impervious Cover Restoration Plan.
- **Identified:** These projects were identified in a Watershed Management Plan (WMP) or other planning document and will be updated in future Restoration Plans as new assessments become available. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They are flagged with a geodatabase status of "proposed" and a have a completion date after June 30, 2019 and before 6/30/2025. These projects are shown in Appendix 3.
- **Potential:** These projects were selected using best available information on costs per BMP, available land or other treatment, and a level of implementation which will meet TMDL requirements. The most cost-effective BMPs implemented by the county (Stream Restoration, Bioswale, and Riparian Forest Buffers) were selected. They will be completed after 6/30/2025 and before 6/30/2052. More detail on **Potential** projects is given in Appendix 4.

UNIQUE PROJECTS AND SCENARIO NESTING

Many of the BMPs used to meet this plan can be used in more than one TMDL. For example, a programmed 113.7 acres of pond retrofits in the Villages of Urbana used to meet the Impervious Cover Restoration Plan will also be used towards the sediment and phosphorus TMDLs for the Lower Monocacy as well as the nitrogen and phosphorus TMDLs for the Chesapeake Bay. These scenarios nest partly or fully inside of each other; the same projects are used to meet each of them because BMPs are duplicated among TMDLs. in most instances, the schedules and costs for the TMDLs are summarized by watershed and not for each of multiple TMDLs in the same watershed.

Schedules and costs are shown for the subset of projects that are in the Impervious Cover Restoration Plan because these projects reflect the efforts that will be completed in the current permit term prior to its expiration on

December 29, 2019. The projects in the Impervious Cover Restoration Plan are consistent with the legislative reporting in the updates to the County's Financial Assurance Plan (FAP) and Watershed Protection and Restoration Plan (WPRP) reports that were submitted to MDE on December 21, 2018. The Previous County FAP was submitted to MDE on July 1, 2016; the previous update to the WPRP report was dated December 30, 2018 as required by the County's MS4 Permit requirements.

The TMDL Restoration Plans and Impervious Cover Restoration Plan have nested relationships. The Chesapeake Bay nitrogen and phosphorus TMDLs contain the BMPs for all Local TMDLs, and the Impervious Cover Restoration Plan. The *E. coli* TMDLs include all BMPs from local TMDLs. The local phosphorus TMDL Restoration Plans include BMPs for all local sediment TMDL Restoration Plans. The Impervious Cover Restoration Plan includes all of the BMPs in the Completed and as subset of Programmed scenarios for all TMDLs to be completed by December 29, 2019.

WATER QUALITY MODELS AND DELIVERY RATIOS

Reductions of nitrogen, phosphorus and sediment for stormwater BMPs are modeled using a customized geodatabase script using loading rates and pollutant removal efficiencies based on Chesapeake Bay Model and MDE SW 2014 parameters. Reductions of bacteria are modeled in the Watershed Treatment Model (WTM) (Caraco, 2013). All of these models contain parameters for calculating pollutant loads from land use, and in the case of WTM, from a number of secondary sources. They also allow the user to predict reductions of pollutants by inputting scenarios with a suite of treatment alternates. The models calculate pollutant reductions based on the amount of treatment and pollutant reduction factors based on the level of treatment.

Pollutant loadings in this plan are expressed in terms of Edge of Stream (EOS) Loads or Delivered (DEL) Loads. EOS loads apply to local waterways and are used for local TMDLs for Phosphorus, Sediment and *E. coli*. DEL loads estimate the attenuated load that makes its way to the mainstem of the Chesapeake Bay. DEL loads are obtained by subtracting the percentage of the EOS load that is attenuated prior to reaching the Bay and are used for Bay TMDL calculations. These calculations are performed in the models based on loading rates derived from the Chesapeake Bay model.

BEST MANAGEMENT PRACTICES USED

All plans in this document include stormwater BMPs accepted in MDE SW 2014. This guidance includes stormwater retrofit projects such as wet pond or wetland conversions and new bioretention facilities as well as alternative practices such as tree planting or stream restoration. Practices in MDE SW 2014 are measured in terms of impervious acres treated and in reductions of nitrogen, phosphorus, and sediment. Most of the pollutant removal efficiencies for these practices come from MDE SW 2014, which addresses impervious acre equivalent, which is specific to Maryland.

As stated earlier, a single practice may give impervious acre credit for the Impervious Cover Restoration Plan and pollutant reductions for multiple TMDL Restoration Plans. Some practices in MDE SW 2014 give credit for impervious surface reduction but not pollutant reductions because the pollutant reductions are credited to another sector; these additional practices include septic system pumping, upgrades, and conversion to sewer. For the *E. coli* portions of the TMDL, BMP efficiencies from the 2013 WTM for many of the same stormwater practices are used; these efficiencies will be revised if better numbers are found in the literature. The WTM also calculates *E. coli* reductions from management programs such as pet waste education and septic system outreach.

More detailed information on management practices, including removal rates for each practice is provided in Appendix 5. The plan also includes credits from water quality trading for the Impervious Cover Restoration Plan as described below.

WATER QUALITY TRADING

MDE's regulations for the Maryland Water Quality trading Program became effective on July 16, 2018. MDE updated its *Draft Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed* (MDE 2017) in April 2017; the document has not yet been finalized. The April 2017 version of the draft trading policy states that "MS4 permittees are allowed to treat a permit-specified portion of their restoration requirement through trading with point and/or nonpoint sources" and that "point and nonpoint source credits can be acquired at any time during the permit term to contribute to an MS4 permittee's restoration requirement." Trading requirements for MS4 communities are also lain out in MDE SW 2014, along with pollutant loads for impervious and forest cover based on statewide averages. MDE has a standing Water Quality Technical Advisory Committee that includes staff from Frederick County Government.

Frederick County's MS4 permit went through a major modification in order to allow for trading. This modification was made final on November 8, 2019. To meet the requirements of the Impervious Cover Restoration Plan, the County plans to use MDE's trading program to generate 574 acres of credits from its wastewater treatment plant at Ballenger McKinney. This plant's permit was recently reissued and includes trading. The County modified its permit with MDE upon reissuance to include the option to generate credits.

To convert impervious acres to pollutant load reductions, MDE proposes to use the alternative practice definition from MDE SW 2014, which is the loading difference between forested and untreated impervious urban acres. The document calculates this difference using statewide average EOS loads in pounds for impervious and forest acres for N, P, and TSS. For every acre of imperviousness met through trading, the jurisdiction needs to obtain credits for all three pollutants: 7.69 pounds of reduction from nitrogen, 1.91 from phosphorus, and 0.43 from TSS.

Table 6: CBP Pollutant Loads for Impervious and Forest Cover (from Table D.1, MDE SW 2014)

Parameter	Impervious (lbs/acre/yr)	Forest (lbs/acre/yr)	Delta (lbs/acre/yr)
TN	10.85	3.16	7.69
TP	2.04	0.13	1.91
TSS (tons)	0.46	0.03	0.43
Source: CBWM 5.3.0 Maryland statewide average urban loading rates without BMPs provided by the Science Services Administration (SSA), MDE, 2011.			

MDE's regulations create a point-to-point credit exchange system using wastewater treatment plant performance below 3mg/l for Nitrogen and below permit limits for other pollutants. Staff from Frederick County Government submitted a comment during a trading webinar with MDE on October 22, 2018; there is currently a type mismatch between the calculation of the credit requirement for MS4s, which is based on EOS loads, and credit generation for WWTPs, which is based on Edge of Tide. Staff from MDE asked Frederick County staff to submit formal comments to this effect on the proposed permit modifications for the large jurisdictions.

Table 7 shows data through October 2019 which has been projected to the end of 2019 to show that the plant generated credits for both nutrients and sediment.

Table 7: Credits generated from Ballenger WWTP

	Performance Based EOS Load (from DMR)					Generated Credits	
	Pounds (Current)	Pounds (Year End Estimate)	Tons	EOT Factor	MDE Reservation	lbs	tons
N	29,665	39,554		0.59	0.95	22,170	
P	4,161	5,548		0.47	0.95	2,477	
Sediment	220,823	294,431	147	0.65	0.95		91

It is anticipated at this time that the County will need approximately 3,876 pounds of N, 963 pounds of P, and 217 tons of TSS to meet its permit requirement. It is anticipated that the Ballenger-McKinney WWTP will have more than adequate credits for Nitrogen and Phosphorus. Should additional sediment credit be needed, the County plans to use a substitution method between N, P, and S used by Anne Arundel in its trading proposal, purchase sediment credits from another plant, and/or generate additional sediment from tree plantings and stream restoration. These credits will need to be purchased every year until the county has replaced them with actual restoration projects; this concept is known as trading in time.

The County, along with other Counties through the Maryland Association of Counties, Metropolitan Washington Council of Governments, and Maryland Municipal Stormwater Association, has repeatedly communicated its concerns with MDE that it is effectively "taking" the 0.9 mg/L of performance beyond permit limits and has set these limits too stringently to consistently provide adequate credits.

IMPLEMENTATION MODELING CALIBRATION

Frederick County's TMDLs were developed by MDE at different periods in time using a variety of models. In order to use a currently available model for analysis, the reduction targets and loads need to be translated or "calibrated" from the model used to develop the TMDL to the current model.

BASELINE MODELING

Baseline loads for each TMDL watershed are based on GIS overlays of the TMDL boundary, the County's MS4 jurisdiction, impervious cover derived from planimetric mapping, and urban land use delineated in MDP's land use/land cover files, and loading rates from two sources, depending on the TMDL:

- TMDL boundaries were downloaded from the MDE TMDL Data Center
- Frederick County's MS4 jurisdiction boundary was delineated by starting with the County boundary, then successively identifying other stormwater permittees and deleting their property. These included Federal lands, State lands, State and local Phase II permittees, MDOT SHA Phase I land, and industrial stormwater permittees.
- The County mapped impervious cover using aerial orthoimagery in 2005, with a subsequent update in 2014.
- MDP mapped land cover statewide in 2002 and 2010. Urban land use includes all codes beginning with 1. Baseline loads do not include land coded 2x (agriculture), 4x (forest), 50 (water), 60 wetlands), 73 (barren), or 241-242 (agriculture). This approach which models loads from urban pervious and impervious developed land use is consistent with the CBWM and allowed the County to use CBWM loading rates.
- Procedures for deriving loading rates and loads are described in the Nutrient/Sediment and *E. Coli* TMDL sections which follow.

Each TMDL has a baseline year, and the GIS overlays were used in the closest approximation, shown in Table 8.

Table 8: GIS Data Used for Baseline Modeling

TMDL	Baseline Year	MDP Land Cover	Frederick Impervious Cover
Sediment	2000	2005	2005
	2005	2005	2005
Phosphorus	2009	2014	2014
Chesapeake Bay Nitrogen, Phosphorus, and Sediment	2010	2014	2014
E. Coli	2004	2005	2005

The baseline model includes County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.

1. County BMPs installed prior to the TMDL baseline year were added to the model.
2. The reduction percentage published in the TMDL document was then applied to the modeled baseline loads to calculate a calibrated reduction in EOS-lbs/yr for local TMDLs and DEL lbs/yr for the Bay TMDL.
3. A calibrated SW-WLA was calculated by subtracting the calibrated reduction from the modeled baseline load.

RESTORATION MODELING

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled using land use loading rates will be the target reductions used for TMDL compliance for the Bay TMDL and all local TMDLs.

Reductions for stormwater treatment have been modeled using a custom geodatabase script that uses the most accurate up-to-date information on BMPs with physical locations. These include all ESD BMPs, all Structural BMPs, and Alternative BMPs.

Reductions for operational BMPs including street sweeping, catch basin cleaning, storm drain vacuuming, and septic system improvements have been determined using current data from County agencies working with these programs. . Load reductions for each type of BMP are based on MDE 2014 Accounting Guidance, (MDE, 2014).

IMPERVIOUS COVER RESTORATION PLAN

Catoctin Creek Nature Center Green Roof

IMPERVIOUS COVER BASELINE

Section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Frederick County states that "within one year of permit issuance, Frederick County shall submit an impervious surface area assessment consistent with the methods described in the MDE document '*Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits*' (MDE, June 2011 or subsequent versions). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit."

The baseline in the previous permit was derived using the Simple Method (Schueler, 1987); which applied impervious cover coefficients to land use/land cover (LU/LC) maps from Maryland Department of Planning. This method has been replaced by the use of planimetric data, where actual impervious areas are digitized from aerial survey.

Frederick County submitted an impervious cover assessment of its MS4 Discharge permit with its first Annual Report under the new permit (Frederick County, 2015). This Assessment was not accepted by MDE, as the County lost a case in the Circuit Court that challenged the definition of the MS4 boundary. MDE instructed Frederick County to resubmit its impervious cover assessment with the December 2018 Annual Report submission.

Frederick County submitted its Fiscal Year 2018 Annual Report in December 2018 as its fourth annual report submission for this permit term. At MDE's request Frederick County included in this report submission a revised impervious cover assessment. MDE provided comments on this annual report submission on July 12, 2019. In the comments, MDE asks Frederick County to provide an updated impervious cover assessment by December 29, 2019.

In its comments, MDE states that it cannot approve the County's revised impervious cover assessment because the County's baseline update did not have adequate documentation to definitively identify the impervious acreages treated by various BMPs in the County's rooftop and non-rooftop disconnect analyses.

Frederick County notes that the revisions to the rooftop and non-rooftop analyses included in the County's 2018 impervious cover assessment resubmission, and reported in the 2018 Annual Report Appendix O: Impervious Accounting Memo and geodatabase, were conducted in the expanded MS4 Boundary. However, the update to the Boundary area was not provided for in Appendices P and Q, Rooftop Disconnect Protocol and Non-Rooftop Disconnect Protocol. Essentially, the revised impervious cover assessment was conducted correctly, but the protocol document language detailing the new extent was not updated when submitted with the 2018 Annual Report.

MDE noted in its August 23, 2019 memo, which tentatively approved the County's Financial Assurance Plan, that approval of the impervious cover assessment was still pending. The County updated the impervious cover assessment as well as two technical memos for rooftop and non-rooftop disconnect studies, and submitted them to MDE on September 30, 2019. Frederick County staff met with MDE on October 24th where it was decided by MDE that the impervious cover analysis was pending approval of the non-rooftop disconnect study. A field visit was planned to review the study findings with MDE; however, McCormick Taylor, in reviewing for the field meeting, discovered a significant error in its work for the rooftop and non-rooftop studies. They had used the wrong projection file that caused the county's restoration obligation to be underestimated by 711 acres. Again, the impervious cover assessment was conducted using the correct boundary and by the correct protocol but with an error in the projection which caused the discrepancy. The County has been working to review the work with the consultants as well as any impacts this error may have created with other studies, and to redouble efforts to look for baseline reduction credits in MDE-approved protocols.

Apart from the rooftop and non-rooftop disconnection issue, MDE stated in a meeting on October 24, 2019 that it accepts the County's methodology for the revised submission, which is the same MDE-approved methodology MDE used with substantially similar results. In some instances, Frederick County had access to better source data, which resulted in slightly different numbers than what MDE calculated from its analysis; the small differences are outlined in the methodologies section of that document.

Frederick County used MDE's guidance and comments to determine there are 13,396 total impervious acres within its boundary, of which 678 acres are treated with BMPs, 403 impervious acres are treated through rooftop disconnect, 2,259 impervious acres are treated through non-rooftop disconnect, 38 acres are treated through sheetflow to conservation areas, 51 acres are treated through existing grass swales and 64 acres are treated by draining to Maryland State Highway Administration BMPs from the Frederick County MS4 area. This leaves the County with 9,903 untreated impervious acres. Based on the 20% restoration requirement, Frederick County will need to treat 1,981 impervious acres to meet its MS4 Permit Restoration requirement.

Table 9: Frederick County Impervious Accounting (6/30/2019)

Impervious Accounting Areas	Area (ac)
Total Impervious area within MS4 Permit Area	13,396
Treated Impervious	(-678)
Rooftop Disconnect	(-403)
Non Rooftop Disconnect	(-2,259)
Existing Grass Swales Districts 3-6	(-51)
SHA Treated County Impervious	(-64)
Sheetflow to Conservation Area	(-38)
Untreated Baseline	9,903
Restoration Goal	**1,981**
Completed as of 6/30/2019	673
Programmed (subset to be completed by 12/31/2019)	804
Nutrient Trading	574
Total Restored	**1,981**

Table 10 shows the current figures on baseline untreated area, restoration from projects and programs established prior to the baseline, and a calculation of the impervious restoration requirement.

RESTORATION EFFORTS FOR 20% OF THE COUNTY'S IMPERVIOUS SURFACE AREA

Sources of the acres restored come from two restoration tiers: **Completed** where the completion date is between March 11, 2007 and June 30, 2019, and **Programmed** prior to December 29, 2019. Restoration projects from the **Completed** scenario built prior to December 30, 2014 are allowed in the Impervious Cover Restoration Plan per MDE because they were executed after March 11, 2007, the ending date of the previous permit. A subset of the **Programmed** projects have been scheduled for completion by December 29, 2019, the end date of the current permit. The remaining **Programmed** projects are scheduled to be complete after the end date of the current permit and are included in assisting in the long-term goals of meeting TMDL SW-WLAs. Future scenarios such as **Identified** and **Potential** begin after the end of the current permit and are not included in the Impervious Cover Restoration Plan, though they are essential towards addressing TMDL SW-WLAs.

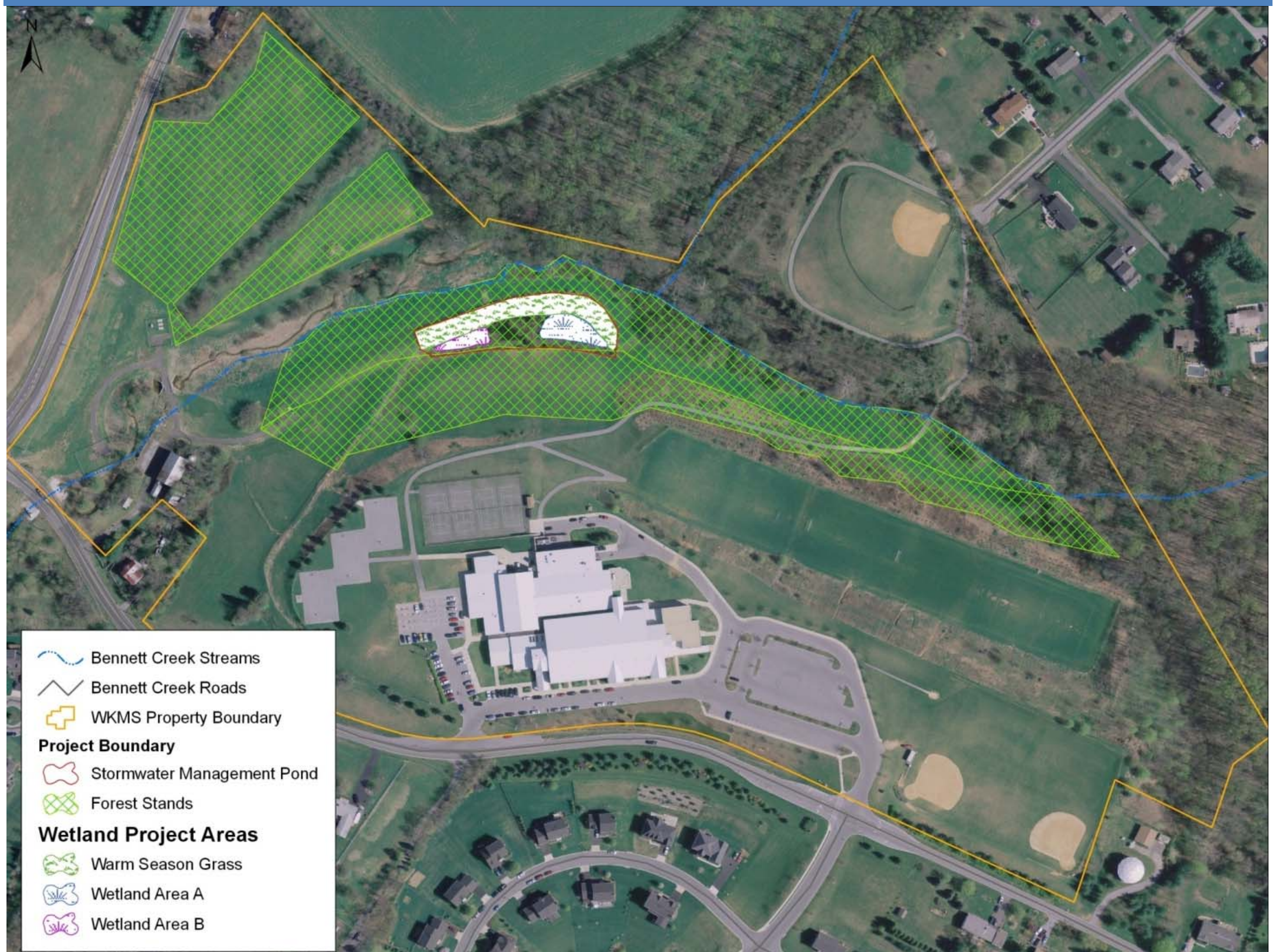
Where there is sufficient information, Frederick County is including alternative BMPs in its restoration plan. These include, but not limited to, street sweeping, outfall stabilization, and a variety of septic system credits along with tree planting and stream restoration. Septic pumpings were added to this plan based on locations extracted from documents acquired from septic maintenance companies as well as the County's new Septic Program Rebate Program. The County reviewed the applicable documents, digitized each address where the septic pumping occurred, and calculated impervious acre equivalency per MDE's guidance (MDE 2014).

Table 10 shows the forecast progress as of the end of the permit term to be over 80 percent of the required total, so over half of the total has been met through restoration approved in MDE's stormwater accounting guidance (MDE SW 2014). Per MDE, a portion of the requirement may be met through credit exchanges in its nascent trading program. The County proposes to address the remaining impervious surface restoration obligation through such trades, described in the Water Quality Trading section in the Introduction. The County is on track to meet its impervious cover restoration requirement.

Table 10: Completed and Programmed Project Impervious Acres by BMP Type by End of the Current Permit

BMP Type	Completed as of 6/30/2019	Programmed (Completed by Dec 29, 2019)	Total
Stormwater			
Micro-Bioretention	2.96		2.96
Rainwater Harvesting	0.05		0.05
Bioretention	1.70		1.70
Wet Pond	72.46	194.35	266.81
Wet Extended Detention	10.31	45.24	55.55
Sand Filter		3.13	3.13
Stream Restoration	288.01	377.63	665.64
Outfall Stabilization	7.33	3.34	10.67
Tree Planting	28.82		117.82
Septic Denitrification	61.88		61.88
Septic Connections to WWTP	2.73		2.73
Septic Pumping	187.14	16.86	204.00
Vacuum Street Sweeping	85.78	8.25	94.03
Redevelopment Restoration	9.60	8.59	8.59
Nutrient Trading		574.44	574.44
Total	**749.17**	**1,237.83**	**1,981.00**

NUTRIENT AND SEDIMENT TOTAL MAXIMUM DAILY LOADS



Windsor Knolls Middle School Tree Planting and Wetland Enhancement

OVERVIEW

The Chesapeake Bay and many local waterways have been listed as impaired due to excessive nitrogen, phosphorus, and sediment. The two nutrients, nitrogen and phosphorus, cause eutrophication by fueling algal blooms that consume dissolved oxygen (DO) needed for other organisms. While sediment causes greater turbidity, blocking sunlight needed for submerged aquatic vegetation (SAV) and reducing this critical habitat for many of the Bay's species.

Degraded habitats in turn reduce biodiversity, which then causes an imbalance in the ecosystem and removes many ecosystem services provided by those organisms. Rich biodiversity keeps all trophic levels intact, supporting fisheries and downstream. Sources of nutrient and sediment impairment have been identified by many different organizations and are discussed below.

Sources of these three pollutants include point sources, such as municipal wastewater facilities, industrial discharge facilities, and NPDES permitted stormwater discharges. Nonpoint sources include agriculture and forest runoff, septic systems, and erosion of streambanks and shorelines. (EPA 2010). Specific sources of each pollutant are described below.

SOURCES OF IMPAIRMENT

NITROGEN

Nitrogen is commonly a limiting nutrient in salt water systems; organisms in both fresh and salt water systems grow most effectively when the soluble nitrogen is found in a ratio of 16:1 relative to phosphorus. As an estuary, the Chesapeake Bay is limited by both nitrogen and phosphorus depending on salinity in different parts of the Bay.

Nitrogen makes up 70 percent of the atmosphere. As a gas, it is inert, but when transformed (fixed) into the reactive forms of nitrate or ammonium it becomes biologically available. Nitrogen fixation can occur naturally, but most reactive nitrogen is man-made, through combustion of fossil fuels, or manufacture of fertilizer. (EPA 2009).

Sources of nitrogen impairment to the Chesapeake Bay include the following (Eney, 2009):

- Manure, emissions and chemical fertilizers from farmland and animal operations (36 percent)
- Nitrogen oxide emissions from vehicles, industries and electric utilities (27 percent)
- Human waste treated and discharged from municipal wastewater treatment plants and wastewater discharged from industrial facilities (20 percent)
- Chemical fertilizers applied to lawns, golf courses and other developed lands (11 percent)
- Septic systems that treat household wastewater and discharge effluent to groundwater in the Bay watershed (5 percent)

PHOSPHORUS

Phosphorus in streams and other waterbodies is found in both dissolved and particulate forms. The only biologically available form is orthophosphate, which is in solution. Most forms bind to soil; as a result it is associated with sediment deposition. This means that freshwater systems, and phosphorus-limited Bay regions, can expect greater phosphorus related algal growth during times of heavy sediment transport. Because phosphorus is less likely to be found in dissolved form, loads may take longer to reach receiving waters, making it more difficult to estimate the effects without long-term monitoring data.

Sources of phosphorus impairment to the Chesapeake Bay include the following (Eney, 2009):

- Manure and chemical fertilizers from farms (45 percent)
- Runoff from developed cities, towns and suburbs, as well as legacy sediments from streams (31 percent)
- Municipal and industrial wastewater (21 percent)

SEDIMENT

Sediment is recognized as one of the most important pollutants to control because it can carry many other harmful substances, such as PCBs, bacteria, or minerals that effect pH. Sediment as a pollutant generally refers to Suspended Solids (SS). The EPA defines SS as mainly inorganic particles consisting of clay and silt less than 0.250 mm in size. While nitrogen and phosphorus contribute to eutrophication via providing nutrients for algal growth, sediment contributes to surface water degradation in local waterways and the Bay, both. Increased sediment deposition changes stream geomorphology, and can also smother bottom-dwelling organisms and make it more difficult for them to feed or filter water.

Sources of sediment impairment to the Chesapeake Bay include the following (Eney, 2009):

- Erosion and runoff from agriculture (60 percent)
- Urban and suburban runoff, construction activity, and in-stream sediment (19 percent)
- Natural sources (21 percent)

CHESAPEAKE BAY (FREDERICK COUNTY) TMDL PLANS BY WATERSHED

The Chesapeake Bay TMDLs, established by the EPA (EPA, 2010), set pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. These TMDLs, required under the Clean Water Act, were in response to the slow progress by states within the watershed to limit their pollutants to levels which meet water quality standards in the Bay and its tidal tributaries. Total limits set in the Bay TMDL for the states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia are “185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year—a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment” (EPA 2010). The TMDL also sets “rigorous accountability measures” for state compliance.

Compliance with the Chesapeake Bay TMDL is regulated in the permit through the use of the 20% impervious surface treatment strategy as described in greater detail in the following section. While not a requirement in the County’s MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress. The results below are shown for information purposes only. This plan reflects the goals of the Phase II WIP, which was still in place June 30, 2019. Future updates will reflect the Phase III WIP that was released in August 2019.

SW-WLAS AND CALIBRATION

Table 11 provides a concise summary of Frederick County’s portions of target edge of stream (EOS) and delivered (DEL) reductions towards the Chesapeake Bay TMDL and 2010 baseline and 2025 allocated loads.

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment. As specified in the Bay TMDL, if the phosphorus target is met, the sediment target will be met.
- **EOS lbs/yr and DEL lbs/yr:** An EOS load is the amount of pollutant that is transported from a source to the nearest stream while a DEL load is the amount of pollutant that is transported to the tidal waters of the Chesapeake Bay. DEL loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **Calibrated 2010 Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector using modeling results from the geodatabase script . Baseline loads were used to calibrate the Bay TMDL nitrogen and phosphorus SW-WLAs.
- **Target Percent Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector (MDE TMDL Data Center). If TP target is met, TSS target will be met.
- **Calibrated Target Reduction:** Target reduction calibrated by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the 2010 baseline levels, calibrated as described above, using the following calculation: 2010 Baseline – (2010 Baseline x Target Percent Reduction); or, 2010 Baseline x (1 – Target Percent Reduction).

Table 11 - Frederick County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN-DEL lbs/yr	TP-DEL lbs/yr
Calibrated Baseline Load	580,252	23,704
Target Percent Reduction	10.9%	20.7%
Calibrated Target Reduction	63,247	4,907
Calibrated Bay TMDL WLA	517,004	18,798

The amount of treatment in progress and proposed to address the Bay TMDL is shown in Table 12. Detailed Chesapeake Bay scenarios are shown in Appendix 6.

Table 12: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	120.83	213.40	334.23
Micro-Bioretention	0.67	0.25	0.92
Dry Swale	25.20	40.80	66.00
Grass Swale	0.30	0.97	1.27
Filters	7.24	2.60	9.84
Wet Pond	1,416.04	3,284.77	4,700.81
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	130,574.80
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	397.06	397.06
Riparian Buffer	0.00	238.16	238.16

NITROGEN TMDL

Table 13: Reductions by Scenario for Chesapeake Bay Nitrogen TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	5,934	5,934	580,252	0.0%
Complete	2,497	2,497	577,755	3.9%
Programmed	12,777	15,274	564,978	24.1%
Identified	2,331	17,605	562,647	27.8%
Potential	27,617	45,222	535,030	71.5%
Calibrated Reduction	63,247			

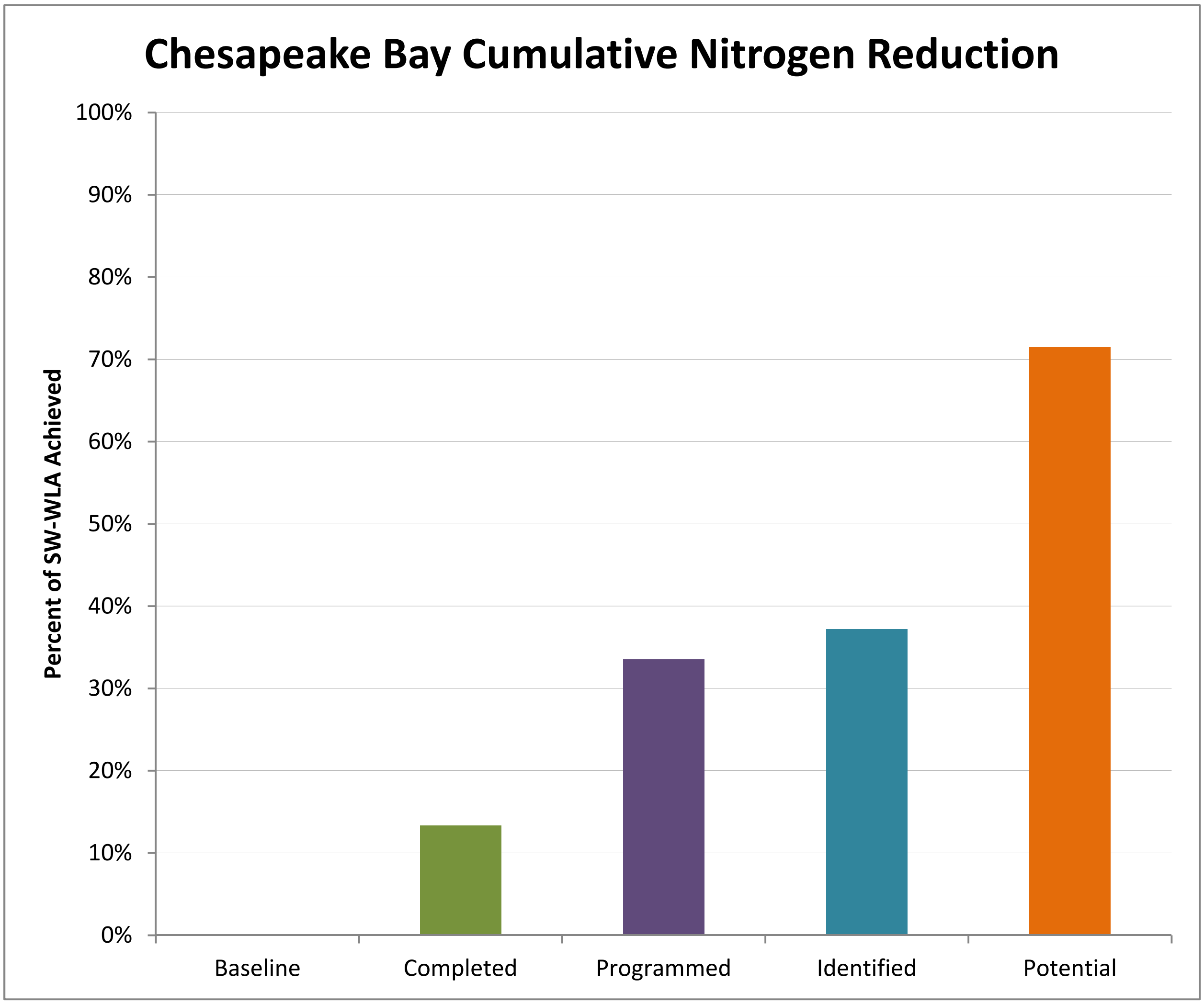


Figure 4: Chesapeake Bay Cumulative Nitrogen Reductions lbs/yr vs. Percent of SW-WLA

PHOSPHORUS TMDL

Table 14: Reductions by Scenario for Chesapeake Bay Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	416	416	23,704	8.5%
Complete	710	710	22,994	14.5%
Programmed	1,536	2,246	21,458	45.8%
Identified	1,252	3,498	20,206	71.3%
Potential	8,254	11,752	11,952	239.5%
Calibrated Reduction	4,907			

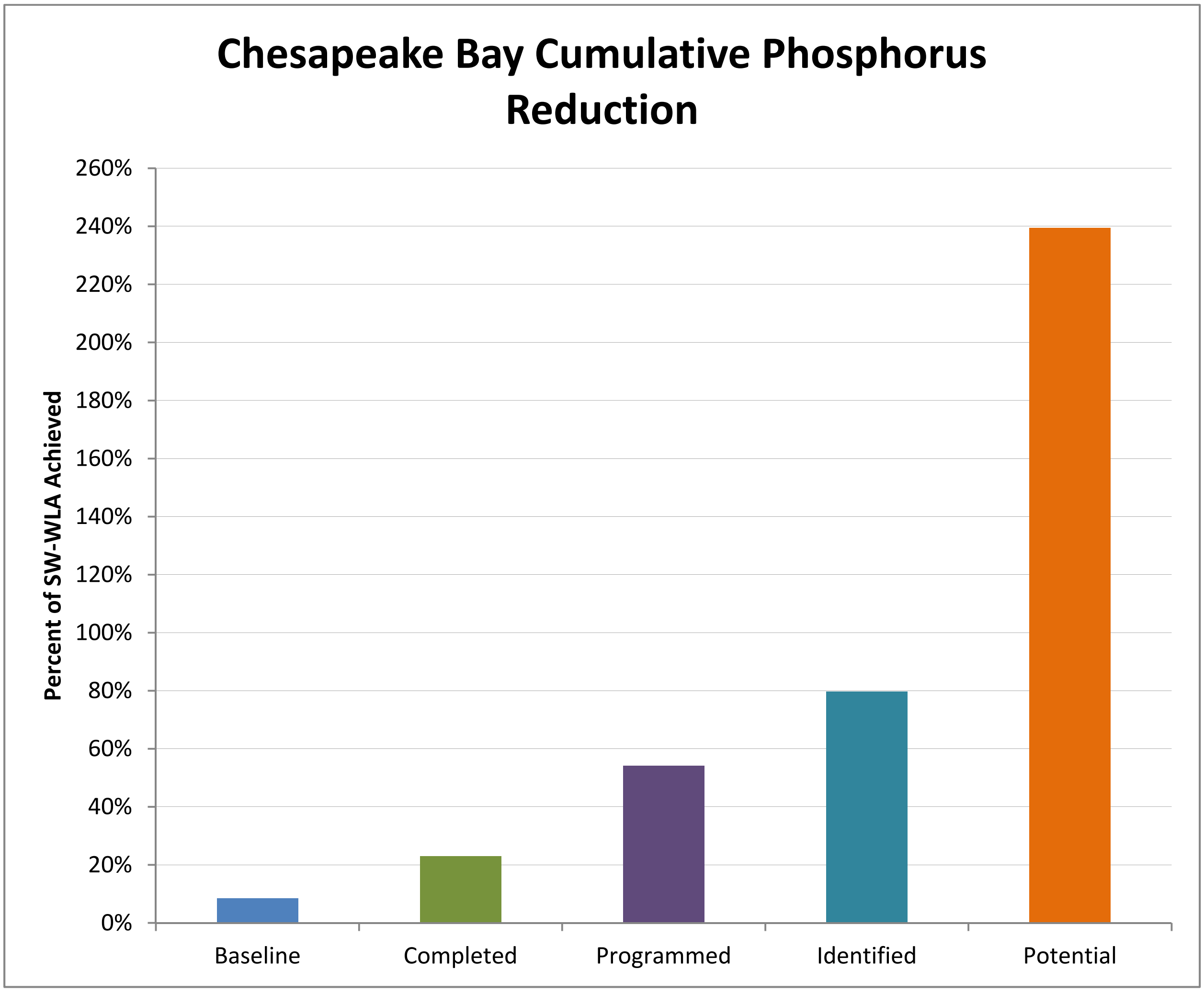


Figure 5: Chesapeake Bay Cumulative Phosphorus Reductions (Percent)

LOCAL NUTRIENT AND SEDIMENT PLANS BY WATERSHED

In order to derive the County MS4-specific SW-WLA load reduction targets, the implementation models used to determine compliance need to be calibrated to TMDL goals using MDE's published reduction percentages for each TMDL. The procedure is described below.

CALIBRATION

Table 15 provides a concise summary of Frederick County's portions of target edge of stream (EOS) and delivered (DEL) reductions towards the nutrient and sediment local TMDLs

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment. As specified in the Bay TMDL, if the phosphorus target is met, the sediment target will be met.
- **EOS lbs/yr and DEL lbs/yr:** An EOS load is the amount of pollutant that is transported from a source to the nearest stream while a DEL load is the amount of pollutant that is transported to the tidal waters of the Chesapeake Bay. DEL loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **MDE Published Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector (MDE TMDL Data Center).
- **Calibrated Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector using modeling results from the geodatabase script.
- **Calibrated Target Reduction:** Target reduction calibrated by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.

Table 15 - Calibrated Nutrient and Sediment Local TMDL SW-WLAs and Target Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction Percent[1]	Baseline Impervious Area[2]	Baseline Pervious Area[2]	Calibrated Baseline Load[3]	Calibrated Reduction[4]
Catoctin Creek	2140305	2009	Phosphorus	11.0%	1,032	8,357	8,656	**952**
		2000	Sediment	49.1%	880	7,666	2,875,114	**1,411,681**
Double Pipe Creek	2140304	2009	Phosphorus	73.0%	103	887	804	**587**
		2000	Sediment	46.8%	65	629	192,286	**89,990**
Lower Monocacy River[5]	2140302	2009	Phosphorus	28.0%	5,407	24,212	29,311	**8,207**
		2000	Sediment	60.8%	4,677	23,355	5,505,954	**3,347,620**
Potomac River Montgomery County	2140202	2005	Sediment	36.2%	0	0	0	**0**
Upper Monocacy River	2140303	2009	Phosphorus	4.0%	1,262	8,340	8,740	**350**
		2000	Sediment	49.0%	1,105	8,006	1,928,453	**944,942**

Target reduction loads used for TMDL compliance shown in bold text.

1) Published Reduction Percent from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County
2) County MS4 urban impervious and pervious acres for the TMDL baseline year.
3) Baseline loads modeled using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.
4) Calibrated reductions calculated by applying the MDE published percent reduction to the calibrated baseline loads.
5) The Lake Linganore watershed is listed under a separate phosphorus and sediment TMDL and is not included in this analysis.

LOWER MONOCACY WATERSHED

SEDIMENT TMDL

The Baseline year for the Lower Monocacy Sediment TMDL was 2000. The TMDL requires a 60.8% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 16 below.

Table 16: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	93.08	185.65	278.73
Micro-Bioretention	2.97	1.45	4.42
Bioswale	25.20	40.80	66.00
Grass Swale	0.30	0.97	1.27
Filters	7.24	2.60	9.84
Wet Pond	926.62	1,883.69	2,810.31
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	84,882.80
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	135.51	135.51
Riparian Buffer	0.00	157.89	157.89

Detail on treatment for each restoration tier for Lower Monocacy sediment are in Appendix 7. Table 17 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 6. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the sediment TMDL will be met in 2042.

Table 17: Reductions by Scenario for Lower Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	0	0	5,505,954	0.0%
Complete	255,698	255,698	5,250,257	7.6%
Programmed	533,157	788,854	4,717,100	23.6%
Identified	100,886	889,740	4,616,214	26.6%
Potential	3,988,857	4,878,597	627,357	145.7%
Calibrated Reduction	3,347,620			

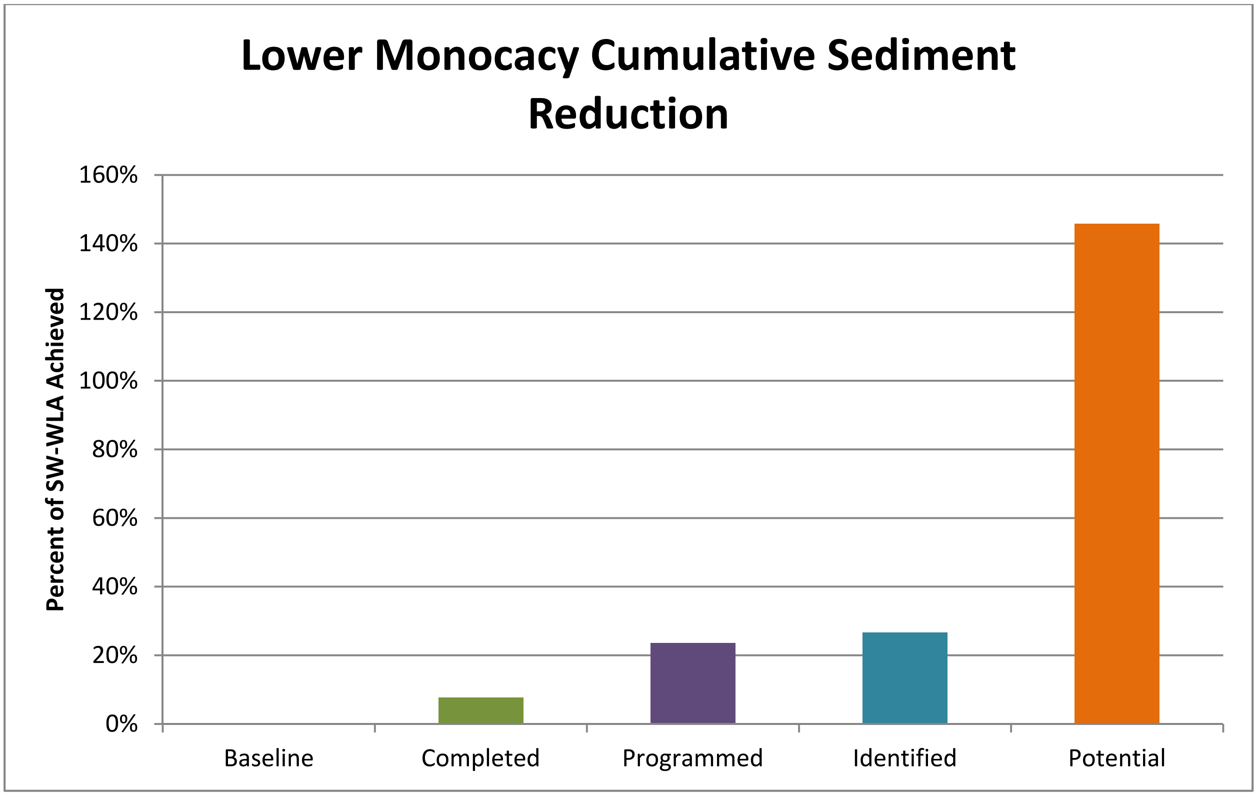


Figure 6: Lower Monocacy Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Lower Monocacy phosphorus TMDL was 2009. The TMDL requires a 28.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 18 below.

Table 18: Cumulative restoration treatment

BMP Type	Treatment (Acres except as noted) Impervious	Pervious	Total
Bioretention	93.08	185.65	278.73
Micro-Bioretention	0.67	0.25	0.92
Bioswale	25.20	40.80	66.00
Grass Swale	0.30	0.97	1.27
Filters	7.24	2.60	9.84
Wet Pond	1,051.21	2,221.63	3,272.84
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	84,828.80
Rainwater Harvesting	0.05	0.00	0.05
Tree Planting	0.00	270.54	270.54
Riparian Buffer	0.00	157.89	157.89

Detail on treatment for each restoration tier for Lower Monocacy phosphorus are in Appendix 8. Table 19 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 7. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the phosphorus TMDL will be met in 2052.

Table 19: Reductions by Scenario for Lower Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	400	400	29,311	4.9%
Complete	433	433	28,478	5.3%
Programmed	1,135	1,567	27,744	19.1%
Identified	381	1,948	27,363	23.7%
Potential	6,263	8,211	21,100	100.0%
Calibrated Reduction	8,207			

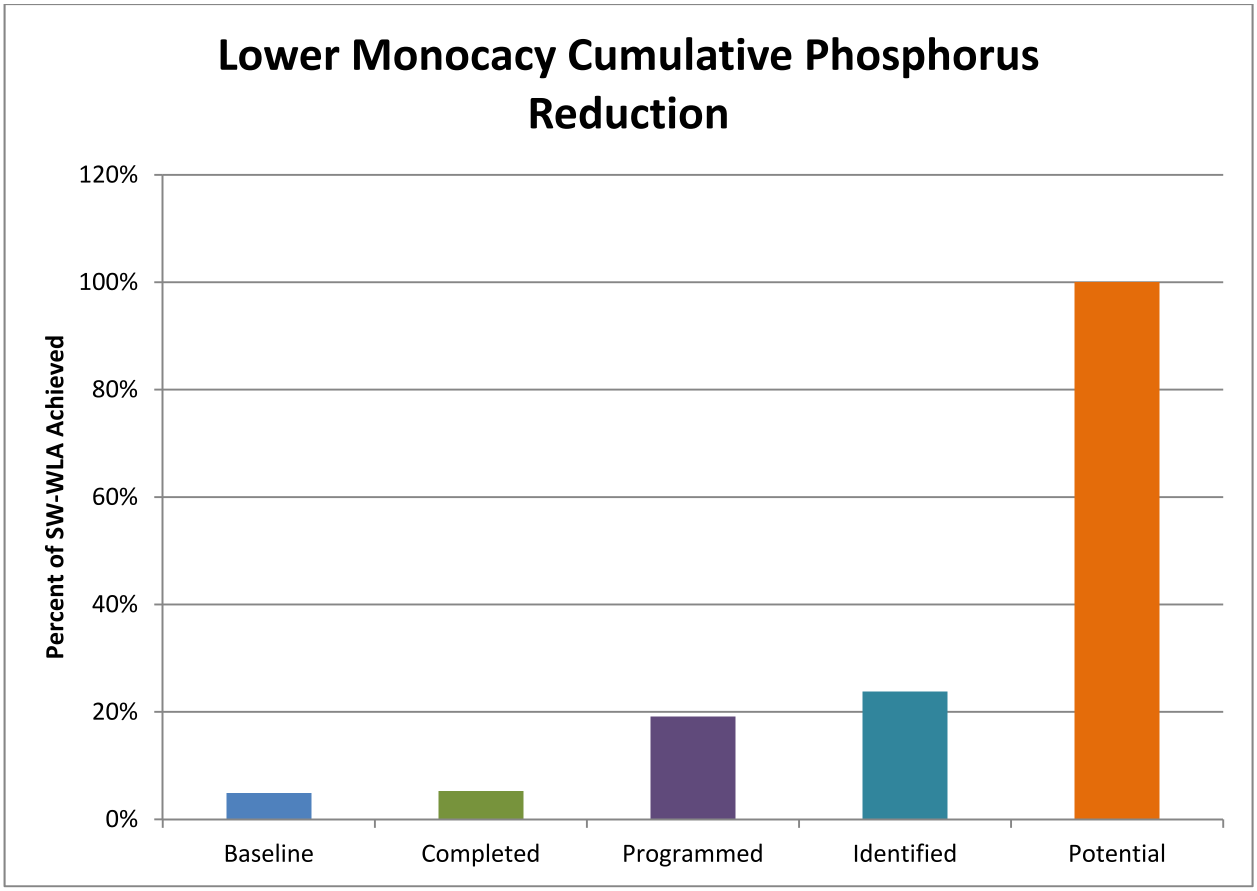


Figure 7: Lower Monocacy Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL

The Baseline year for the Upper Monocacy Sediment TMDL was 2000. The TMDL requires a 60.8% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 20 below.

Table 20: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	27.75	27.75	55.50
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	96.83	233.28	330.11
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	16,661.50
Tree Planting	0.00	70.68	70.68
Riparian Buffer	0.00	36.84	36.84

Detail on treatment for each restoration tier for Upper Monocacy sediment are in Appendix 9. Table 21 shows the calibrated load reductions for each of the restoration tiers, also shown in

Figure 8. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the Sediment TMDL will be met in 2033.

Table 21: Reductions by Scenario for Upper Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	0	0	1,928,453	0.0%
Complete	153,737	153,737	1,774,717	16.3%
Programmed	152,617	306,354	1,622,100	32.4%
Identified	116,868	423,222	1,505,232	44.8%
Potential	522,278	945,500	982,954	100.1%
Calibrated Reduction	944,942	1,890,442		

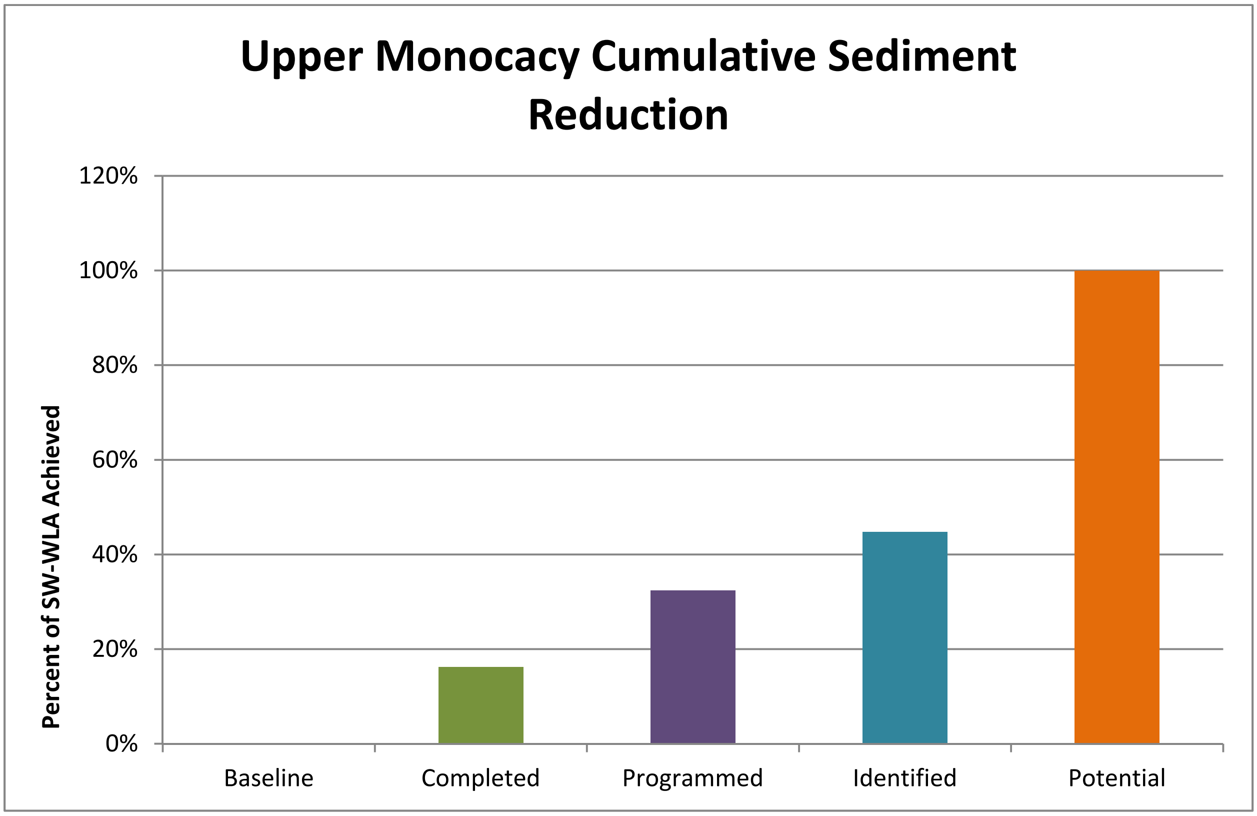


Figure 8: Upper Monocacy Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Upper Monocacy phosphorus TMDL was 2009. The TMDL requires a 4.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 22 below.

Table 22: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	**Impervious**	**Pervious**	**Total**
Bioretention	27.75	27.75	55.50
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	96.83	233.28	330.11
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	16,661.50
Tree Planting	0.00	69.91	69.91
Riparian Buffer	0.00	36.84	36.84

Detail on treatment for each restoration tier for Upper Monocacy phosphorus are in Appendix 10. Table 23 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 9. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated the Phosphorus TMDL will be met in 2024.

Table 23: Reductions by Scenario for Upper Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	52	52	8,740	14.8%
Complete	232	232	8,508	66.4%
Programmed	235	468	8,273	133.8%
Identified	164	632	8,109	180.7%
Potential	773	1,405	7,336	401.8%
Calibrated Reduction	350			

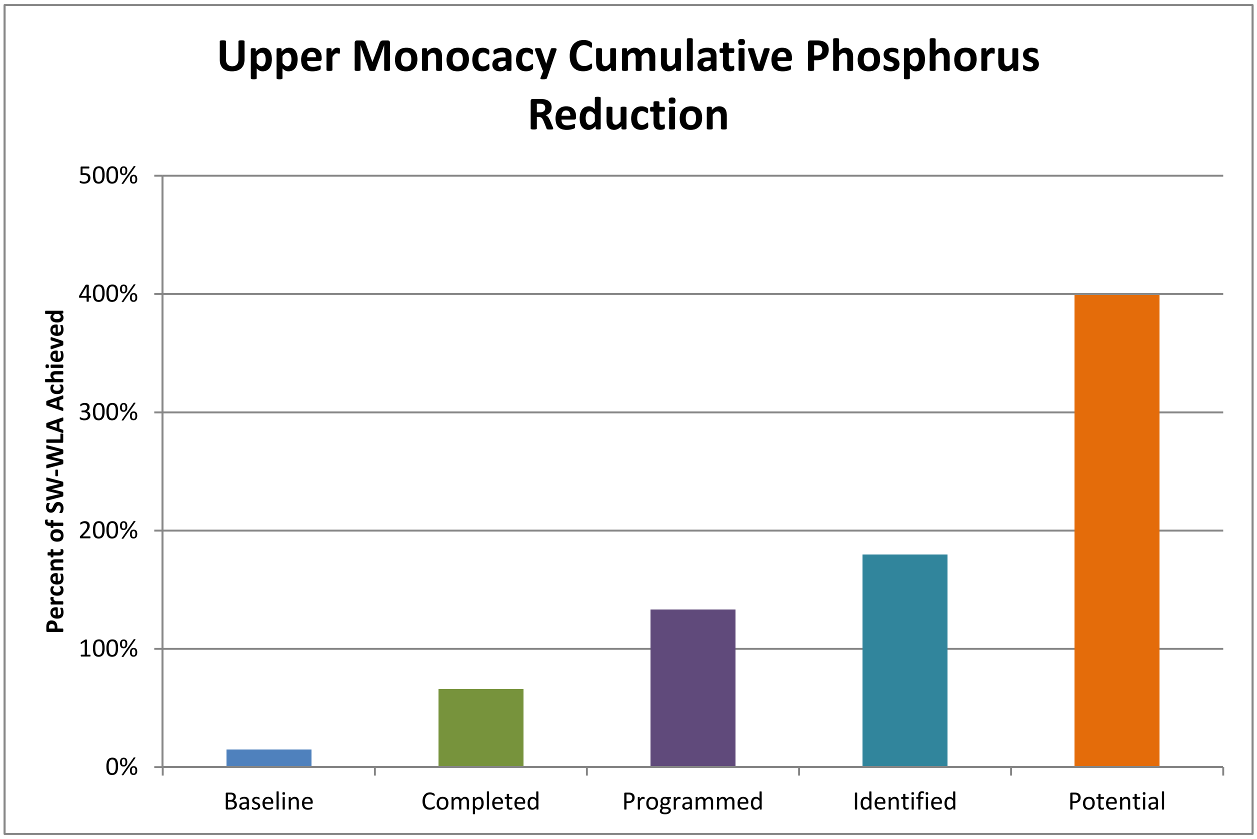


Figure 9: Upper Monocacy Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL

The Baseline year for the Catoctin Creek Sediment TMDL was 2000. The TMDL requires a 49.1% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 24 below.

Table 24: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	268.00	829.86	1,097.86
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	21,269.50
Tree Planting	0.00	47.89	47.89
Riparian Buffer	0.00	26.32	26.32

Detail on treatment for each restoration tier for Upper Monocacy sediment are in Appendix 11. Table 25 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 10. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the sediment TMDL will be met in 2033.

Table 25: Reductions by Scenario for Catoctin Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	0	0	2,875,114	0.0%
Complete	18,819	18,819	2,856,295	1.3%
Programmed	285,057	303,876	2,571,238	21.5%
Identified	297,957	601,832	2,273,282	42.6%
Potential	811,315	1,413,147	1,461,967	100.1%
Calibrated Reduction	1,411,681			

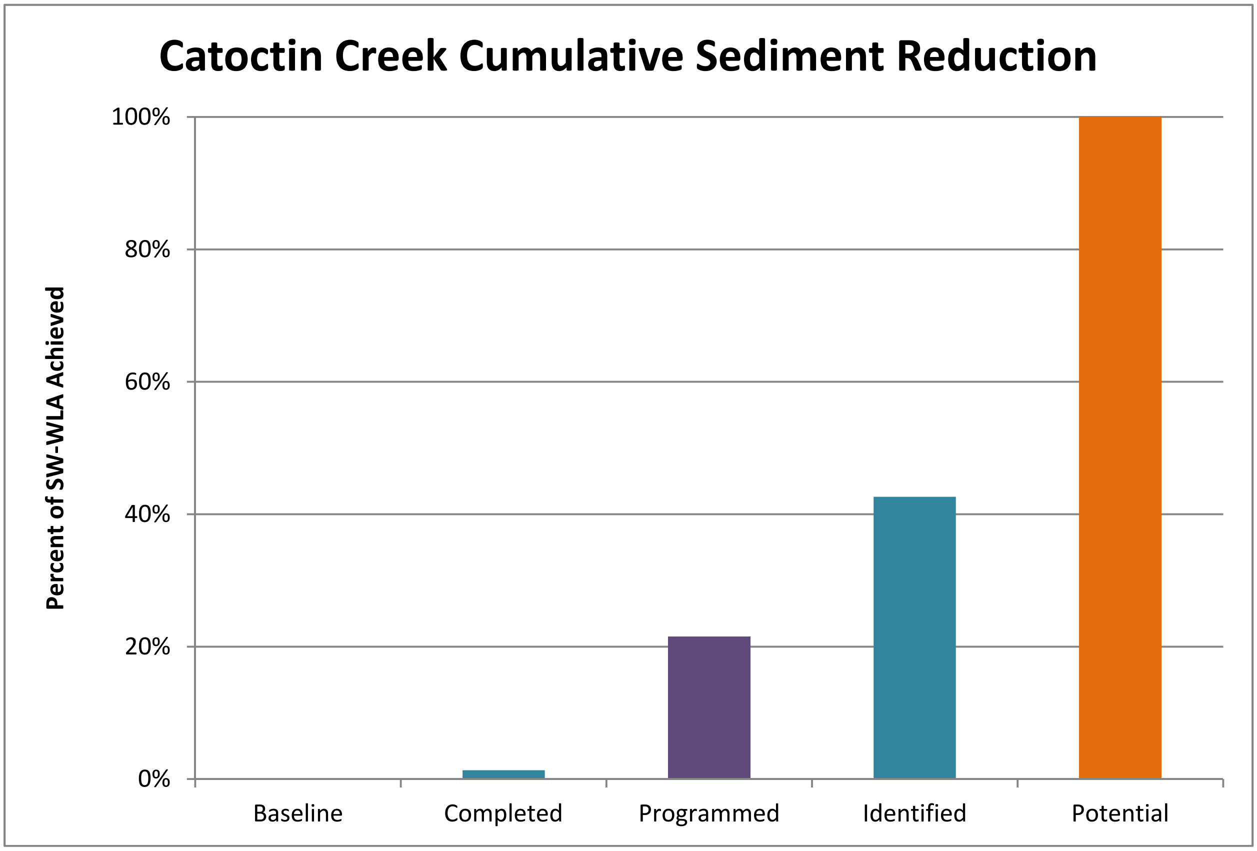


Figure 10: Catoctin Creek Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL

The Baseline year for the Catoctin Creek phosphorus TMDL was 2009. The TMDL requires an 11.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 26 below.

Table 26: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	268.00	829.86	1,097.86
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	21,269.50
Tree Planting	0.00	45.17	45.17
Riparian Buffer	0.00	26.32	26.32

Detail on treatment for each restoration tier for Catoctin Creek phosphorus are in Appendix 12. Table 27 shows the calibrated load reductions for each of the restoration tiers, also shown in

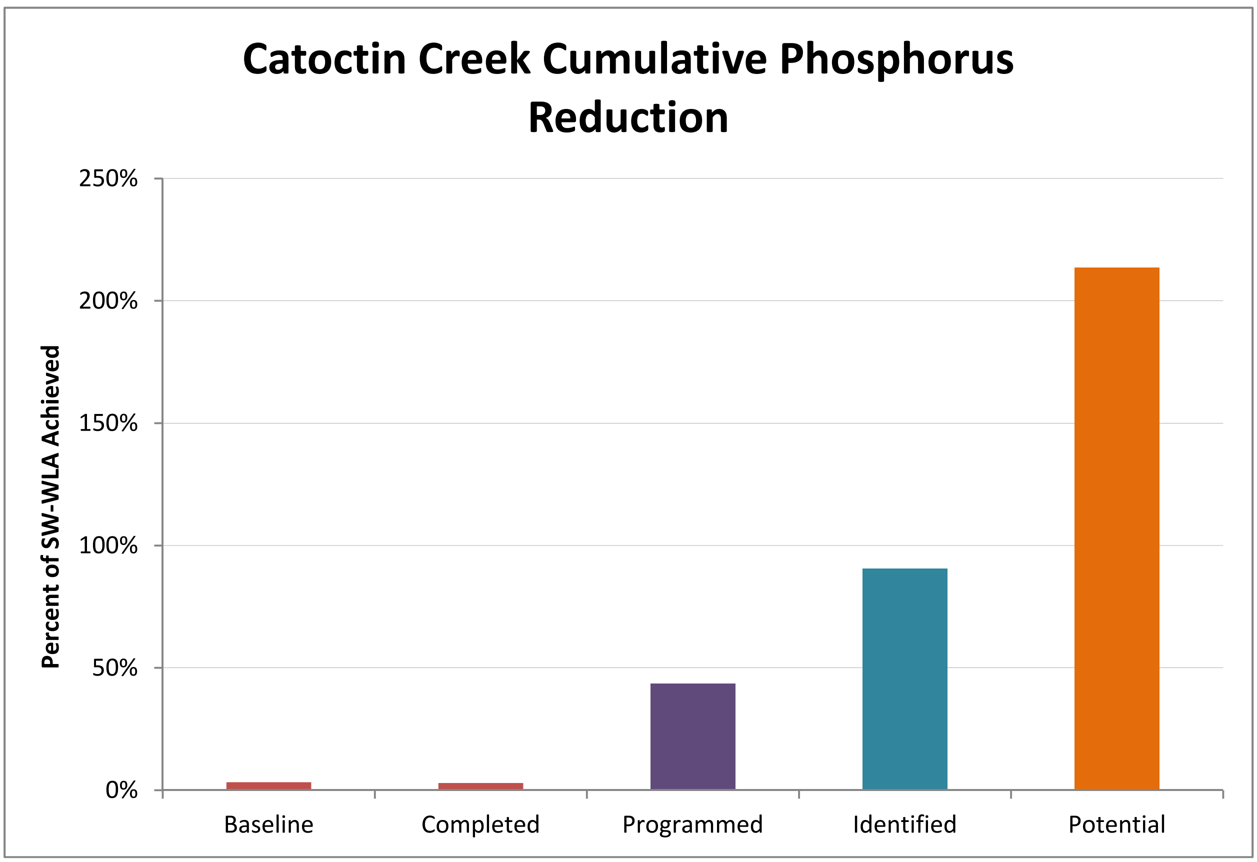


Figure 11. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the phosphorus TMDL will be met in 2027.

Table 27: Reductions by Scenario for Catoctin Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	31	31	8,656	3.3%
Complete	28	28	8,629	2.9%
Programmed	387	415	8,242	43.6%
Identified	448	863	7,793	90.6%
Potential	1,170	2,033	6,623	213.5%
Calibrated Reduction	952			

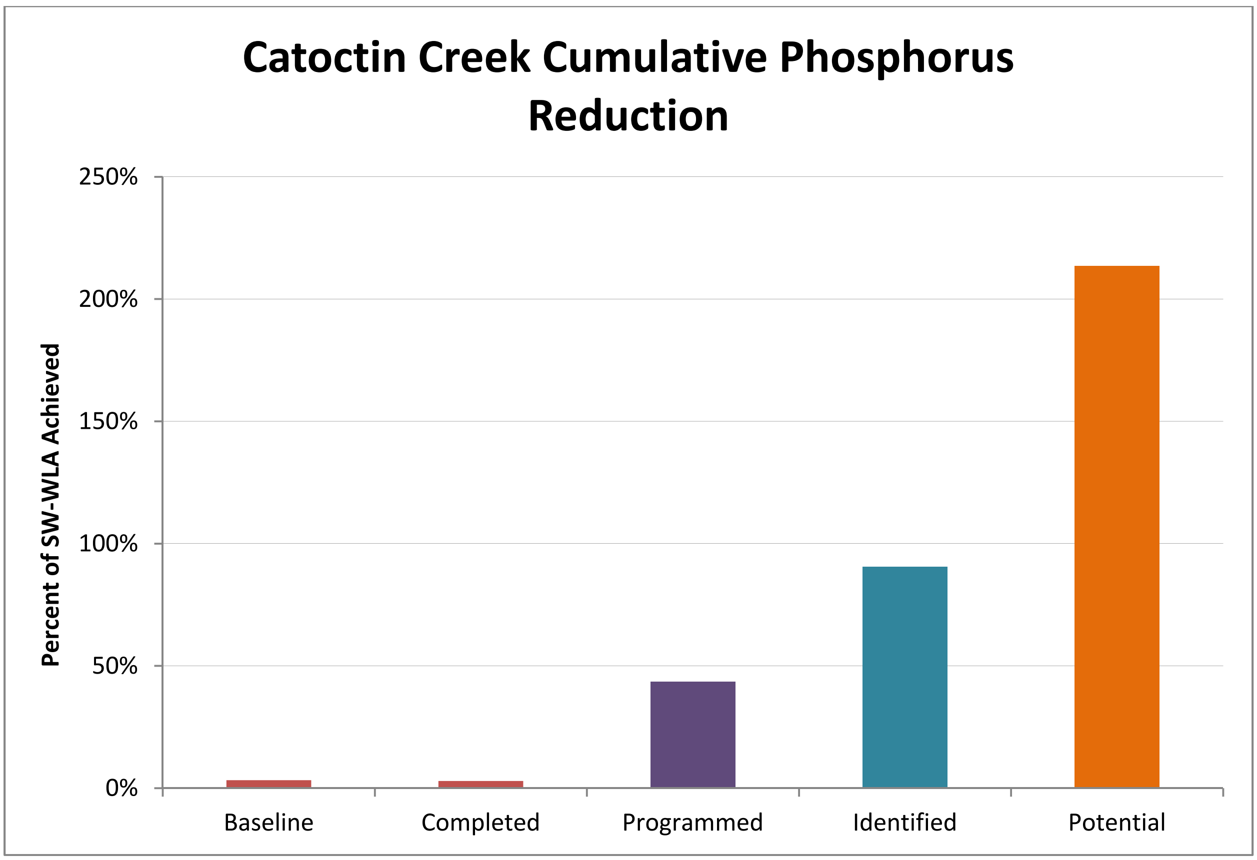


Figure 11: Catoctin Creek Cumulative Phosphorus Reductions (Percent)

SEDIMENT TMDL:

The Baseline year for the Double Pipe Creek Sediment TMDL was 2000. The TMDL requires a 46.8% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 28 below.

Table 28: Cumulative restoration treatment

	Treatment (Acres except as noted)		
BMP Type	Impervious	Pervious	Total
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	0.00	0.00	0.00
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	8,815.00
Tree Planting	0.00	11.44	11.44
Riparian Buffer	0.00	17.11	17.11

Detail on treatment for each restoration tier for Double Pipe Creek sediment are in Appendix 13. Table 29 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 12. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the sediment TMDL will be met in 2023.

Table 29: Reductions by Scenario for Double Pipe Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	0	0	192,286	0.0%
Complete	65,924	65,924	126,362	73.3%
Programmed	1,239	67,163	125,123	74.6%
Identified	304,425	371,588	-179,302	412.9%
Potential	28,563	400,151	-207,865	444.7%
Calibrated Reduction	89,990			

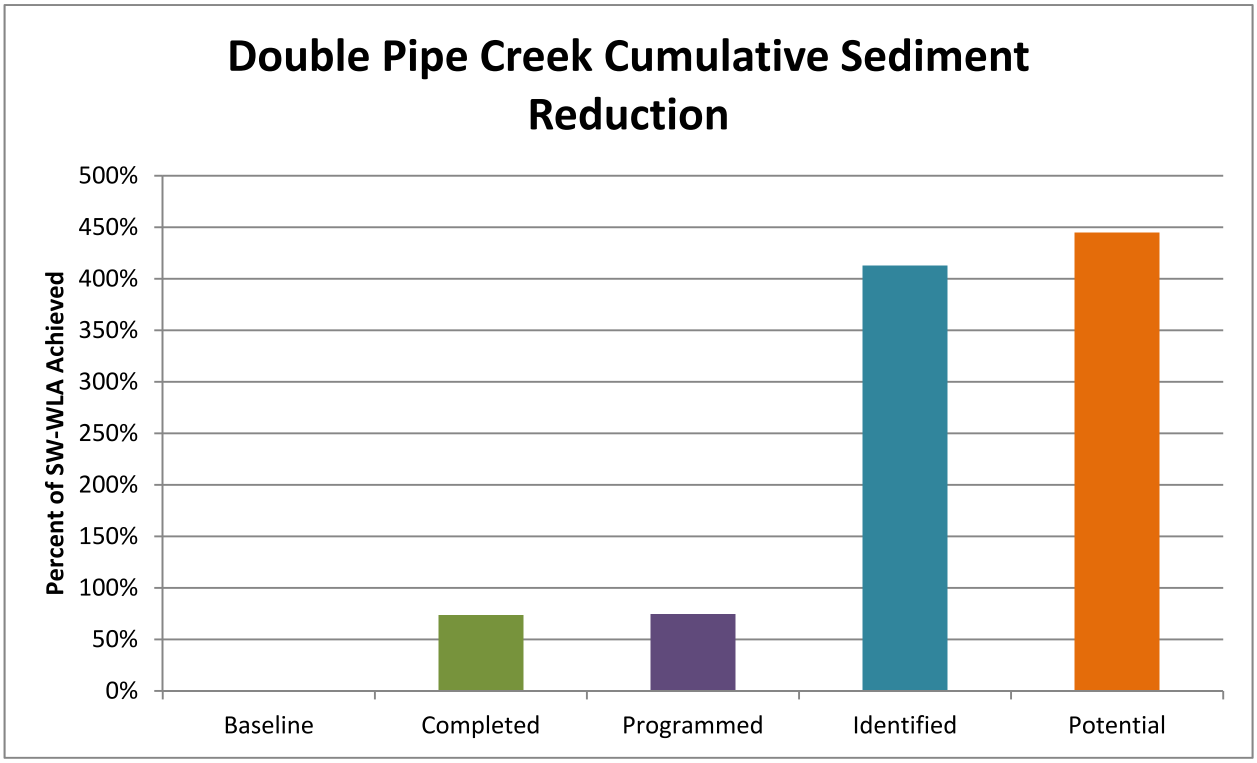


Figure 12: Double Pipe Creek Cumulative Sediment Reductions (Percent)

PHOSPHORUS TMDL:

The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009. The TMDL requires a 73.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in Table 30: Cumulative restoration treatment below.

Table 30: Cumulative restoration treatment

BMP Type	Treatment (Acres except as noted) Impervious	Pervious	Total
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	0.00	0.00	0.00
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	8,815.00
Tree Planting	0.00	11.44	11.44
Riparian Buffer	0.00	17.11	17.11

Detail on treatment for each restoration tier for Double Pipe Creek phosphorus are in Appendix 14. Table 31 shows the calibrated load reductions for each of the restoration tiers, also shown in Figure 13. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the phosphorus TMDL will be met in 2025.

Table 31: Reductions by Scenario for Double Pipe Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cumulative Reduction lbs/yr	Load lbs/yr	% of Required Reduction
Baseline	0	0	804	0.0%
Complete	100	100	704	17.1%
Programmed	3	104	700	17.7%
Identified	460	564	240	96.0%
Potential	43	607	197	103.4%
Calibrated Reduction	587			

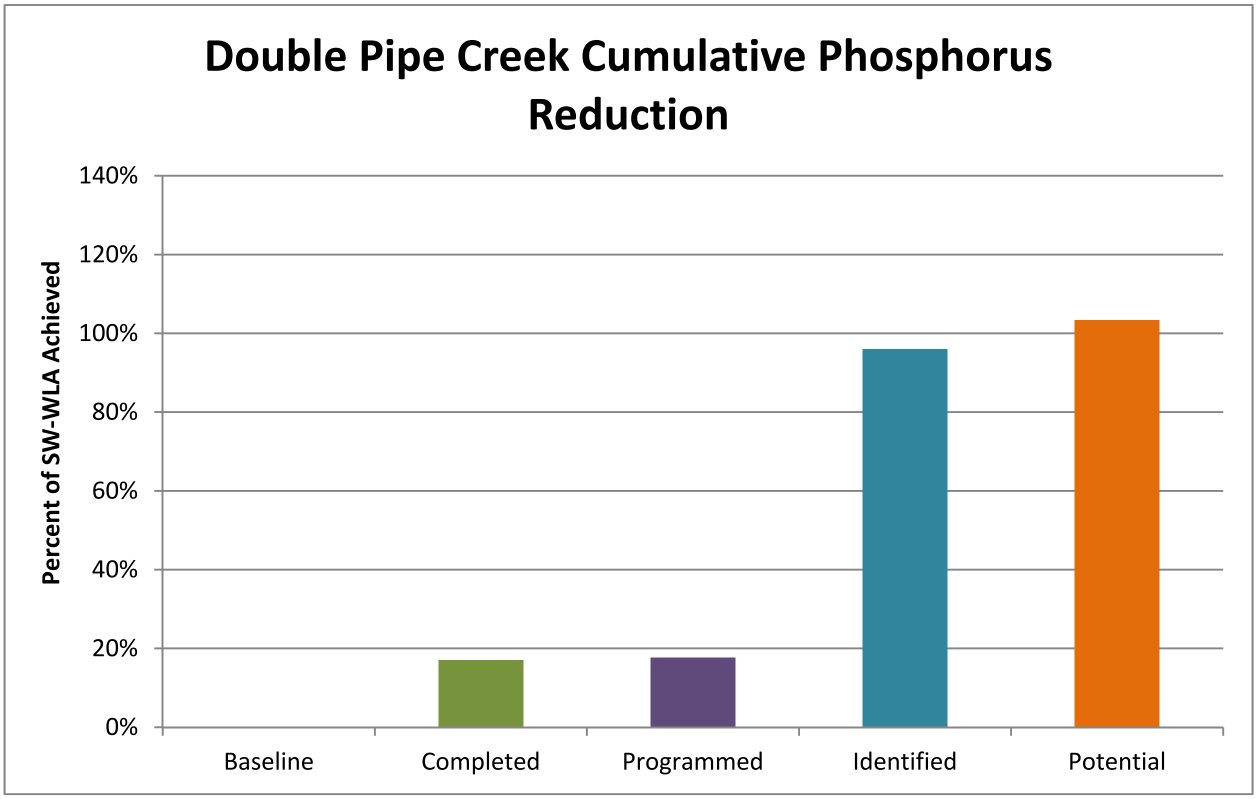


Figure 13: Double Pipe Creek Cumulative Phosphorus Reductions (Percent)

POTOMAC DIRECT (MONTGOMERY COUNTY) WATERSHED

SEDIMENT TMDL:

The Baseline year for the Potomac Direct Sediment TMDL was 2005. The TMDL requires a 36.2% reduction from baseline. However, the County is not proposing restoration measures at this time.

The Maryland Department of Planning (MDP) GIS land use layer from 2002 was used to delineate urban areas for baseline load calculations. The analysis showed no urban area in the County's portion of this small watershed, which was confirmed through review of digital aerial imagery. As a result, with the more detailed data and modeling available for this Plan, there are no calculated loads and no feasible sites for treatment. The County anticipates that baseline load modeling will be reviewed in the future with potential better information from the Phase 6 CBWM.

CONCLUSION

The nine local sediment and phosphorus TMDLs addressed in this document are shown in the table below. Each TMDL's SW-WLA for Frederick County Government's MS4 is met by this Plan. Figure 14 shows a comparison between the required and achieved reduction expressed as a percent.

Table 32: Local Phosphorus and Sediment TMDLs with Calibrated SW-WLAs and Reductions Achieved

Watershed Name	Pollutant	Calibrated Baseline Load EOS-lbs/yr	Calibrated WLA EOS-lbs/yr	Calibrated Reduction Required EOS-lbs/yr	Calibrated Reduction Achieved EOS-lbs/yr	Percent Reduction Achieved
Catoctin Creek	Phosphorus	8,656	7,704	952	2,033	213.5%
	Sediment	2,875,114	1,463,433	1,411,681	1,413,147	100.1%
Double Pipe Creek	Phosphorus	804	217	587	612	104.3%
	Sediment	192,286	102,296	89,990	403,668	448.6%
Lower Monocacy River	Phosphorus	29,311	21,104	8,207	8,211	100.0%
	Sediment	5,505,954	2,158,334	3,347,620	4,878,597	145.7%
Potomac River Montgomery County	Sediment	0	0	0	0	N/A
Upper Monocacy River	Phosphorus	8,740	8,391	350	1,405	401.8%
	Sediment	1,928,453	983,511	944,942	945,500	100.1%

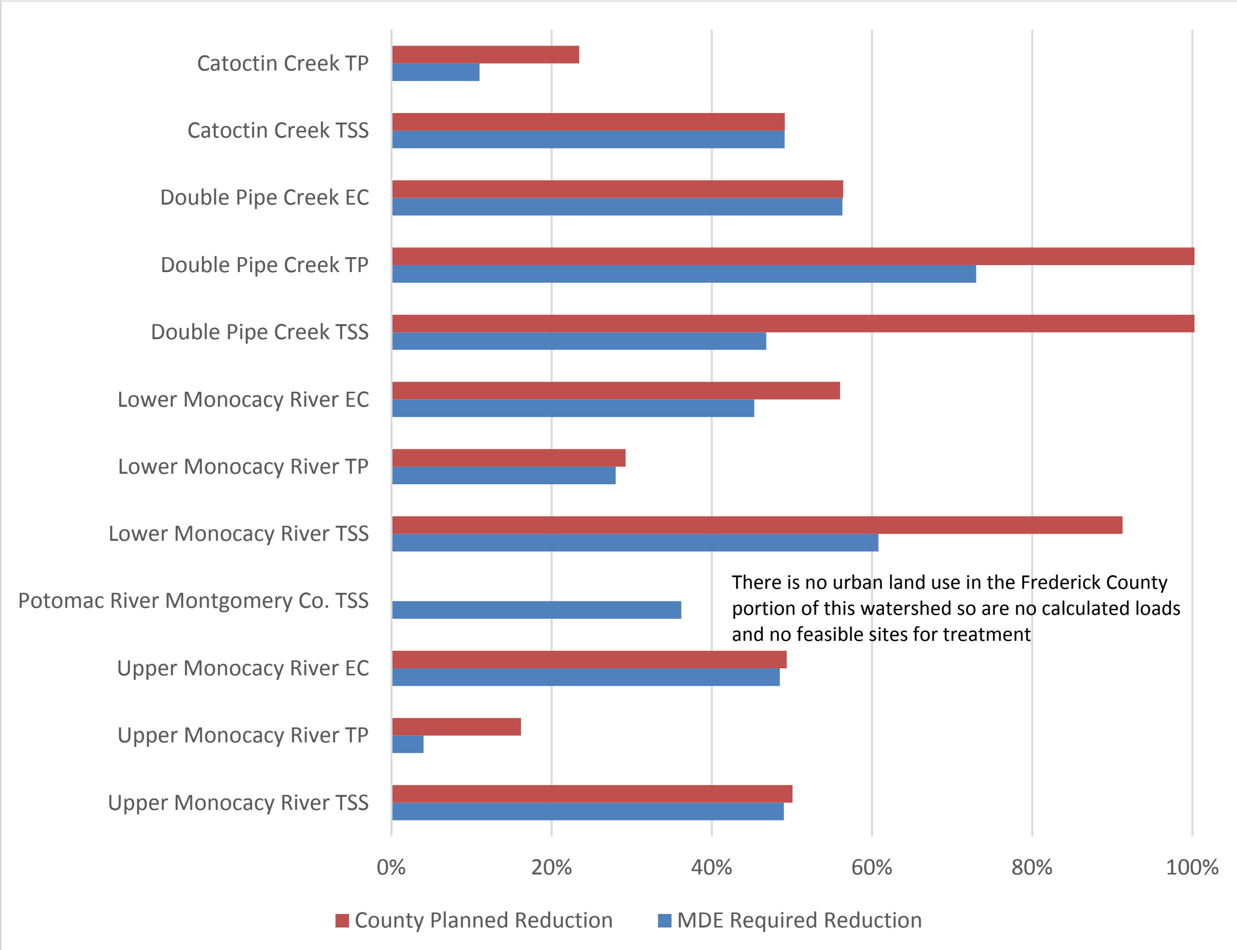


Figure 14: Phosphorus and Sediment Percent reduction required and planned per watershed

The following reductions are achieved under the Chesapeake Bay TMDL Restoration Plan for Nitrogen and Phosphorus:

Table 33: Delivered loads in Chesapeake Bay TMDL Restoration Plans

Pollutant	Calibrated Baseline Load DEL-lbs/yr	Calibrated WLA DEL-lbs/yr	Calibrated Reduction Required DEL-lbs/yr	Calibrated Reduction Achieved DEL-lbs/yr	Percent Reduction Achieved
Nitrogen	580,252	517,004	63,247	49,649	78.5%
Phosphorus	23,704	18,798	4,907	12,407	252.9%

Septic Tank Replacement with Denitrification

E. COLI AS A SOURCE OF IMPAIRMENT

E. coli is a single celled bacteria that falls into a class of fecal coliform bacteria, which is a subclass of total coliform bacteria. Originating in the excrement of warm-blooded animals, some strains of *E. coli* pose a risk for "body-contact recreation, for consumption of molluscan bivalves (shellfish), and for drinking water. Excessive amounts of fecal bacteria in surface water used for recreation are known to indicate an increased risk of pathogen-induced illness to humans. Infections due to pathogen-contaminated recreation waters include gastrointestinal respiratory, eye, ear, nose, throat, and skin diseases (MDE LM 2009)." Per MDE, the key priority for plans to reduce *E. coli* is to "address human sources due to the greater health risk". (MDE Bacteria 2014)

For the TMDL analysis, "Bacteria source tracking (BST) was used to identify the relative contributions from various sources of bacteria to in-stream water samples…Sources are defined as domestic (pets and human associated animals), human (human waste), livestock (agricultural animals), and wildlife (mammals and waterfowl). To identify sources, samples are collected within the watershed from known fecal sources, and the patterns of antibiotic resistance of these known sources are compared to isolates of unknown bacteria from ambient water samples." (MDE DP 2009)

SOURCES OF IMPAIRMENT AND CONTROL

The graphic below is from Byappanahalli (2012). According to the graphic, "sources of enterococci in water bodies (blue arrows) as well as sinks where enterococci are immobilized (yellow arrow) and areas of flux, in which enterococci can transition from a reservoir to the water column and vice versa (green arrows). Fluxes act as secondary sources or sinks depending upon the conditions."

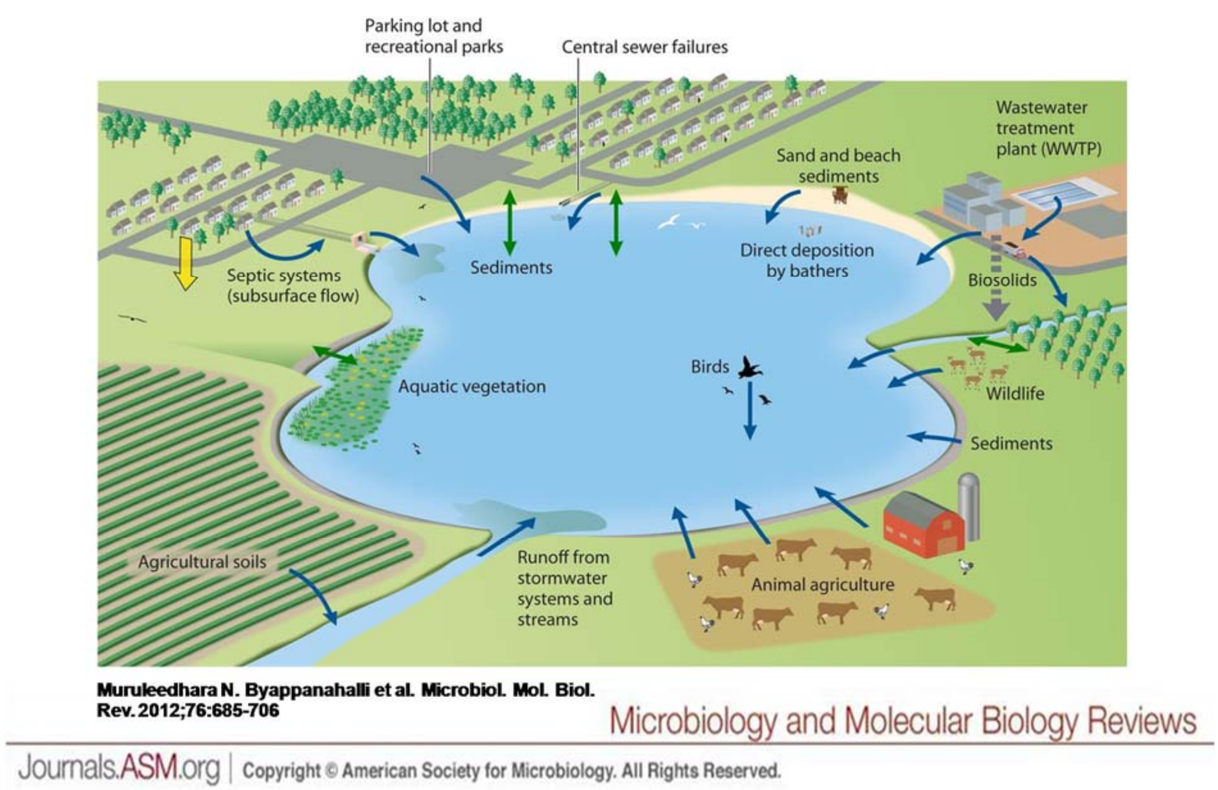


Figure 15: Sources and Sinks of *E. coli* from Byappanahalli 2012

Bacteria come from multiple sources, which can be classified as either human, domestic pets, livestock, or wildlife. The most common sources of human-specific bacteria are sanitary sewer overflows (SSO), leaking sewer infrastructure, illicit connections, or failed septic systems. Bacteria can originate from pet waste that is not disposed of properly. Livestock are another source of bacteria, especially agricultural feeding operations. Finally, bacteria can come from wildlife living in the watershed, in both urban and forested areas.

As can be seen in Figure 15: Sources and Sinks of *E. coli* from Byappanahalli 2012, stormwater runoff is a significant pathway, conveying bacteria from many of these sources to the waterbody, including pet waste, livestock manure, wildlife droppings and SSOs. Dry weather contamination comes from wastewater sources: septic systems and sewers and direct deposition. Livestock which are allowed access to water in streams can be a major source of direct manure deposits.

TMDL GOALS

Similarly to nutrient and sediment TMDLs, the *E. coli* TMDLs assign a WLA which must be met for compliance. Unlike them; however, these three TMDLs have also been given a Maximum Practicable Reduction (MPR) which acknowledges the fact that it may not be possible to reduce some of the loads. For example, in Double Pipe Creek, the TMDL (MDE DP 2009) states:

> *...water quality standards cannot be attained in any of the seven Double Pipe Creek subwatersheds, using the Maximum Practical Reduction (MPR) scenario. MPRs may not be sufficient in subwatersheds where wildlife is a significant component or where very high reductions of fecal bacteria loads are required to meet water quality standards. In these cases, it is expected that the MPR scenario will be the first stage of TMDL implementation.*

The MPR targets are established for each of the bacteria sources, as follows:

Table 34: MPR Targets by Bacteria Source

Max Practicable Reduction per Source	Human	Domestic	Livestock	Wildlife
	95%	75%	75%	0%
Rationale	(a) Direct source inputs. (b) Human pathogens more prevalent in humans than animals. (c) Enteric viral diseases spread from human to human	Target goal reflects uncertainty in effectiveness of urban BMPs and is also based on best professional judgment	Target goal based on sediment reductions from BMPs and best professional judgment	No programmatic approaches for wildlife reduction to meet water quality standards. Waters contaminated by wild animal wastes offer a public health risk that is orders of magnitude less than that associated with human waste.

For the MPR, MDE envisions a phased in approach (MDE DP 2009):

MDE intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality and human health risk, with consideration given to ease of implementation and cost. The iterative implementation of BMPs in the watershed has several benefits: tracking of water quality improvements following BMP implementation through follow-up stream monitoring; providing a mechanism for developing public support through periodic updates on BMP implementation; and helping to ensure that the most cost-effective practices are implemented first.

The discussion of treatment and reductions achieved that follow will include both the WLA and MPR where appropriate.

CALIBRATION

Unlike TMDLs for nutrients and sediment, MDE's bacteria TMDLs were not prepared using a watershed model. All loads discussed in the bacteria TMDLs are based on monitoring in the impaired waterbody. Fate and transport from the watershed are not accounted for, including the quantity of bacteria from various sources in the watershed, die-off (or growth) in transit to the waterbody, potential sequestering and resuspension from bottom sediments, or other factors.

Implementation modeling and calibration were performed using a revised version of the Watershed Treatment Model (Caraco, 2013) that allowed for modeling of all scenario tiers in one Excel workbook and only modeled bacteria. Inputs for loads were organized by Primary Sources, which are calculations of runoff loads by land use type and area within the watershed, and Secondary Sources, which calculated sewage-related loads.

PRIMARY SOURCES

The model uses a variation of the Simple Method (Schueler, 1987) to calculate loads from urban areas. The Simple Method requires area and percent impervious for each land use to calculate annual runoff, and an Event Mean Concentration (EMC) to calculate loads. Loads were calculated using EMCs reported in the National Stormwater Quality Database (NSQD) (Pitt et al., 2004). EMCs used in the model are shown in Table 35, which also cross-references land use categories from MDP and the NSQD.

Table 35: EMCs Used for Modeling

MDP Land Use	MDP LU Codes	NSQD Land Use	EMC (MPN/100 mL)
Residential	11,12,13,191,192	Residential	8,345
Open Urban	18	Open Space	7,200
Commercial / Institutional	14,16	Commercial (1)	4,300
Roadway	80	Freeways	1,700

SECONDARY SOURCES

Secondary sources are pollutant sources that cannot be calculated based on land use information alone. The sources used in the model included potential urban bacteria sources, such as septic systems, CSOs SSOs, and illicit discharges. County GIS data on miles of sanitary sewer, sewered and unsewered areas, and residential parcels were used to develop input data.

CALIBRATED SW-WLAS AND REDUCTION TARGETS

In order to help pinpoint sources, Bacteria Source Tracking (BST) was included in each of the TMDLs to identify relative contributions from various sources of bacteria to in-stream water samples. BST uses DNA, RNA, or patterns of antibiotic resistance to categorize the fraction of bacteria coming from the four general sources described above: humans, domestic pets, wildlife, or livestock for the watershed as a whole. Consistent with MDE guidance (MDE, 2014) the two sources which addressed in this plan are human and domestic. Livestock sources are treated by agricultural BMPs, which are not included in treatment for the MS4. Similarly, wildlife sources (other than urban wildlife) are not treated by BMPs or management measures associated with the MS4.

In all three of the bacteria TMDLs, two reduction percentages are shown: the Maximum Practicable Reduction (MPR) and the target reduction for the SW-WLA. MPR is based on reductions for each of the four source categories. Human sources potentially have the highest risk of causing disease, so the maximum reduction was set at 95%. The domestic pet reduction was based on an estimated success of education and outreach programs, set at 75%. The livestock target, also 75%, was based on the level of sediment reductions from agricultural BMPs. Wildlife reductions were assumed to be 0%. Table shows the results of the calibration analysis.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled as described above will be the target reductions used for TMDL compliance local TMDLs. These values are presented in bold in the Calibrated Reduction column of Table 36, which provides a concise summary of Frederick County's portions of target loads and reductions for the three *E. coli* TMDLs.

- **MDE Published Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector from MDE Data Center (http://wlat.mde.state.md.us/ByMS4.aspx). Based on meeting Water Quality Standards (WQS).
- **MDE Published MPR:** Percent reduction based on MPR.
- **MDE Published Human and Domestic BST:** Percent of TMDL load which was determined to be from these sources based on BST analysis.
- **Target BST WLA Reduction:** Calculated from published reductions: Published Reduction x BST Human-Domestic).
- **Target BST WLA Reduction:** Calculated from published reductions: Published MPR Reduction x BST Human-Domestic).
- **Calibrated Baseline Load**: Baseline loads (i.e., loads with baseline BMPs) from land use runoff loads modeled in WTM, along with secondary loads from septic systems, SSOs, and illicit discharges. Loads from domestic pets and urban wildlife are included in runoff loads from urban land. Baseline loads were used to calibrate the target reductions for the SW-WLA and MPR.
- **Calibrated BST WLA Reduction:** Target reduction calibrated by multiplying the product of the published reduction percent and the BST percentage for human and domestic sources by the calibrated baseline load.
- **Calibrated MPR WLA Reduction**: Target reduction calibrated by multiplying the product of the MPR reduction percent and the BST percentage for human and domestic sources by the calibrated baseline load.

Table 36: Calibrated *E. coli* Local TMDL Target Load Reductions

Watershed Name	Baseline Year	MDE Published Reduction Percent[1]	MDE Published MPR Percent[2]	MDE Published Human and Domestic BST Percent[2]	Target BST WLA Reduction Percent[4]	Target BST MPR Reduction Percent[4]	Calibrated Baseline Load bn MPN/yr[3]	Calibrated BST WLA Reduction bn MPN/yr[4]	Calibrated BST MPR Reduction bn MPN/yr[4]
Double Pipe Creek	2004	98.80%	80.80%	57.00%	56.32%	**46.06%**	57,383	32,317	**26,429**
Lower Monocacy River	2004	92.50%	76.06%	49.00%	45.33%	**37.27%**	4,423,422	2,004,916	**1,648,583**
Upper Monocacy River	2004	97.00%	85.33	50.00%	48.50%	**42.67%**	1,136,894	551,394	**485,056**

Target reduction loads used for TMDL compliance shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County

2) Published MPR % and BST% from TMDLs for each watershed.

3) Baseline loads modeled in WTM using County BMPs installed prior to the TMDL baseline year on top of baseline runoff loads from MDP urban land use and secondary sources.

4) Calibrated reductions calculated by applying the product of the BST Human/Domestic percent and the MDE published percent reduction to the WTM calibrated baseline loads.

DOUBLE PIPE CREEK WATERSHED

MDE completed monitoring of Double Pipe Creek in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the portion of the watershed in Frederick County, sections of Little Pipe Creek and Sam's Creek watersheds, has been designated as Use IV-P (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). MDE developed a TMDL for *E. coli* in Double Pipe Creek in 2009 (MDE DP 2009) which was approved by EPA in 2009. The portion of Double Pipe Creek that is in Frederick County is rural, with its main stormwater inputs from roads and rural residences. There are no sewer lines in this portion of the watershed. BST monitoring "was conducted at six stations throughout the Double Pipe Creek watershed, where 12 samples (one per month) were collected. To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL are shown in the graph below.

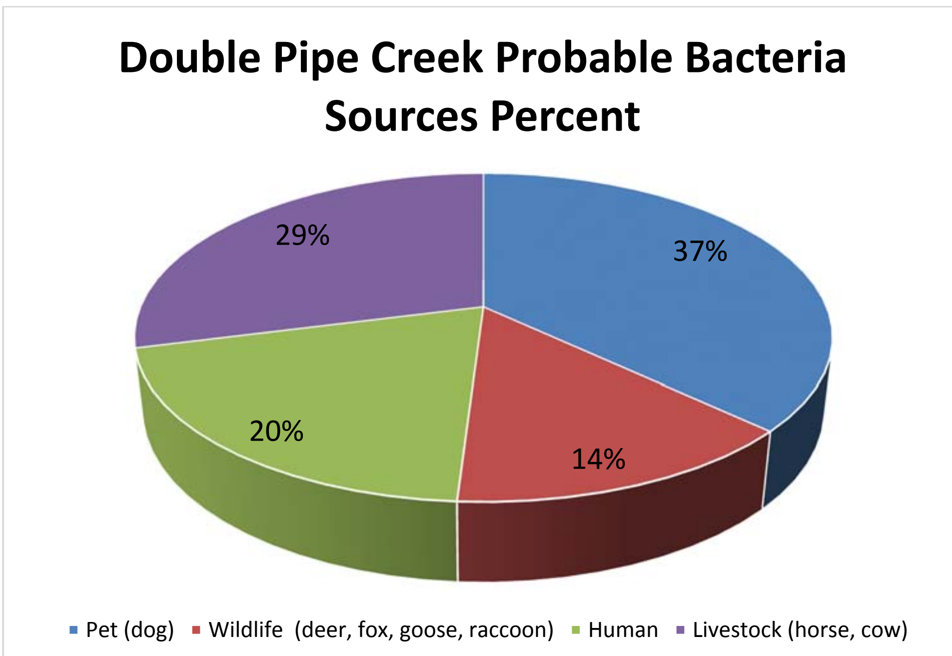


Figure 16: Double Pipe Probable Bacteria Sources Present

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR, provided in MDE DP 2009.

Table 37: MPR Percent Derivation for Double Pipe Creek based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	6,568.6	80.8%
Domestic	75%	3,075.9	
Wildlife	0%	930.1	
Livestock	75%	0.0	

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in Table 38 and Table 39. Detail on the amount of treatment modeled in each scenario is provided in Appendix 17.

Table 38: Cumulative restoration treatment

	Total Restoration (ac except as noted		
BMP Type	IA	Pervious	DA
Bioretention	0.00	0.00	0.00
Bioswale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	0.00	0.00	0.00
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	8,815.00
Tree Planting	0.00	28.54	28.54
Riparian Buffer	0.00	17.11	17.11

Table 39: Cumulative restoration treatment for alternative bacteria BMPs

Alternative BMPs	Total Restoration	
Pet Waste Education	32	households
Street Sweeping	0	
Impervious Disconnection	0	
Land Use Change – Vacant to Forest	254	acres
Illicit Connection Removal	0%	remediated
SSO Repairs	0%	remediated
Septic System Pumping	349	systems
Septic System Repair	75	systems
Septic System Upgrade	6	systems
Septic System Retirement	0	systems

Table 40 shows the calibrated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 17.

Table 40: Reductions by Scenario for Double Pipe Creek Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	0	0	57,385	0.0%	0.0%
Complete	1,817	1,817	55,568	5.6%	6.9%
Programmed	1,057	2,874	54,511	8.9%	10.9%
Identified	4,641	7,514	49,870	23.3%	28.4%
Potential	25,316	32,831	24,554	101.6%	124.2%
Calibrated Required BST WLA Reduction		32,317			
Calibrated Required BST MPR Reduction		26,429			

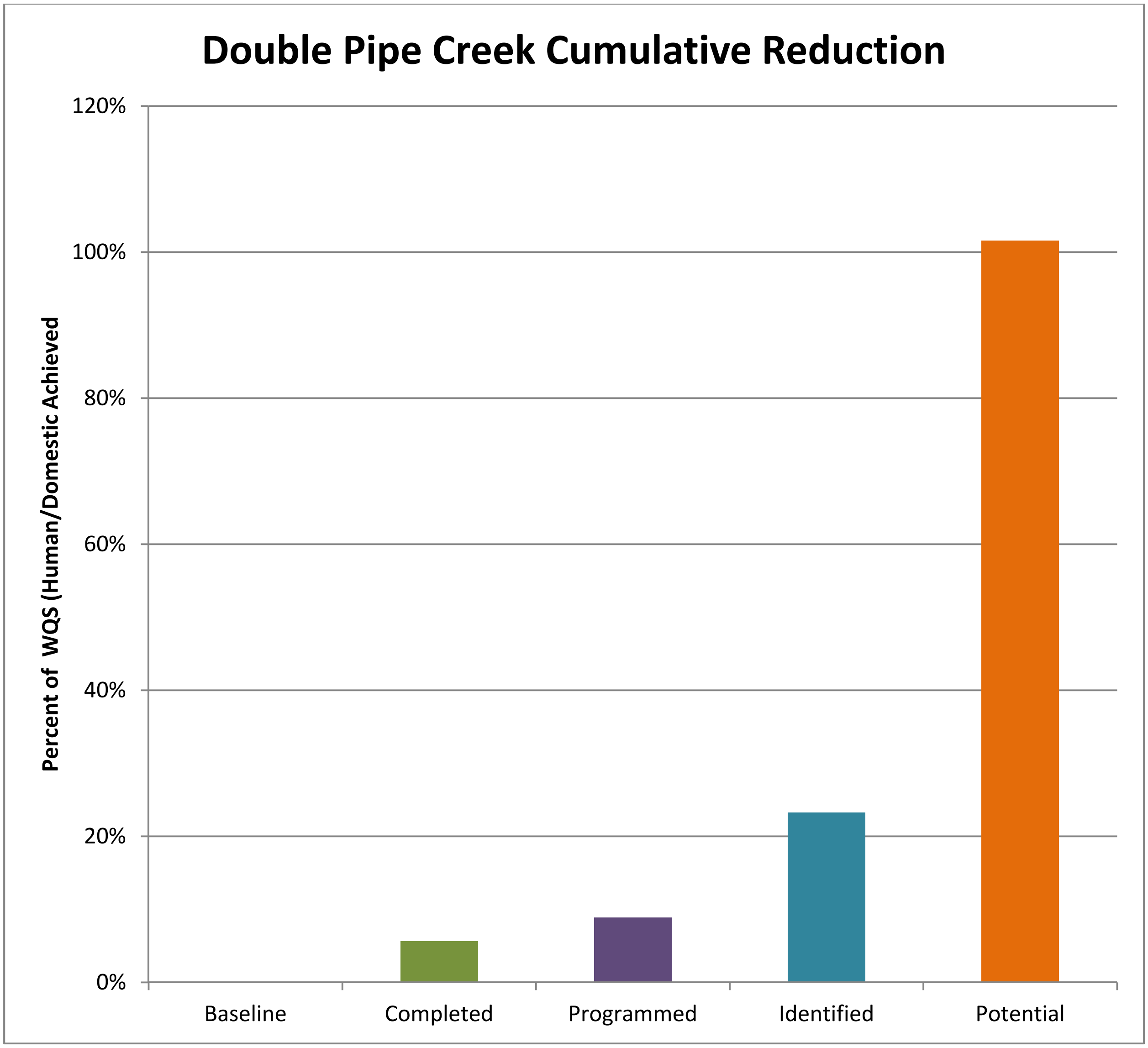


Figure 17: Double Pipe Creek Cumulative Reduction (Percent of SW-WLA)

The Both the MPR and the WLA targets for human/domestic sources will be met with the Potential treatment tier. The County will take an Adaptive Management approach to this TMDL, focusing on remediating human sources of bacteria first, implementing structural BMPs according to the schedule, and monitoring the results to determine if additional treatment will be necessary.

LOWER MONOCACY WATERSHED

MDE completed monitoring of Lower Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the Lower Monocacy River upstream of US Route 40 and the tributary Israel Creek are designated as Water Use IV-P (Recreational Trout Waters and Public Water Supply). Downstream of US Route 40, the Lower Monocacy River has a Use I-P designation (Water Contact Recreation, Protection of Aquatic Life and Public Water Supply). Other tributaries such as Carroll Creek, Rocky Fountain Run, Little Bennett Creek, Furnace Branch, Ballenger Creek and Bear Branch are designated as Use III-P water bodies (Non-tidal Cold Water and Public Water Supply).

MDE developed a TMDL for *E. coli* in the Lower Monocacy in 2009 (MDE LM 2009) which was approved by EPA in 2009. The portion of the Lower Monocacy watershed that is in Frederick County covers the city of Frederick and the towns of Walkersville, Woodsboro, and Mount Airy. The watershed's main stormwater inputs are from roads and residences. There are 311.1 miles of sanitary sewer in this portion of the watershed, and only 3% of the dwelling units are unsewered. During development of the TMDL, Bacterial Source Tracking monitoring was conducted at nine stations throughout the Lower Monocacy watershed, and 12 samples (one per month) were collected throughout the duration of one year. Two stations in the Upper Monocacy River basin were included in the TMDL analysis to determine the TMDL for the portion of land not accounted for in the Upper Monocacy TMDL.

To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL (MDE LM 2009) are shown in the graph below.

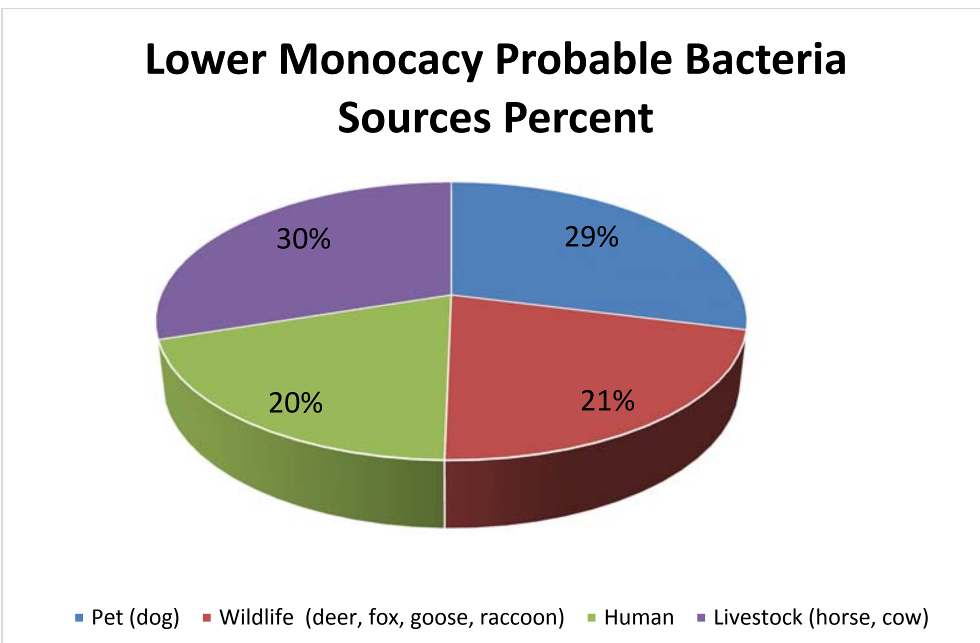


Figure 18: Lower Monocacy Probable Bacteria Sources Present

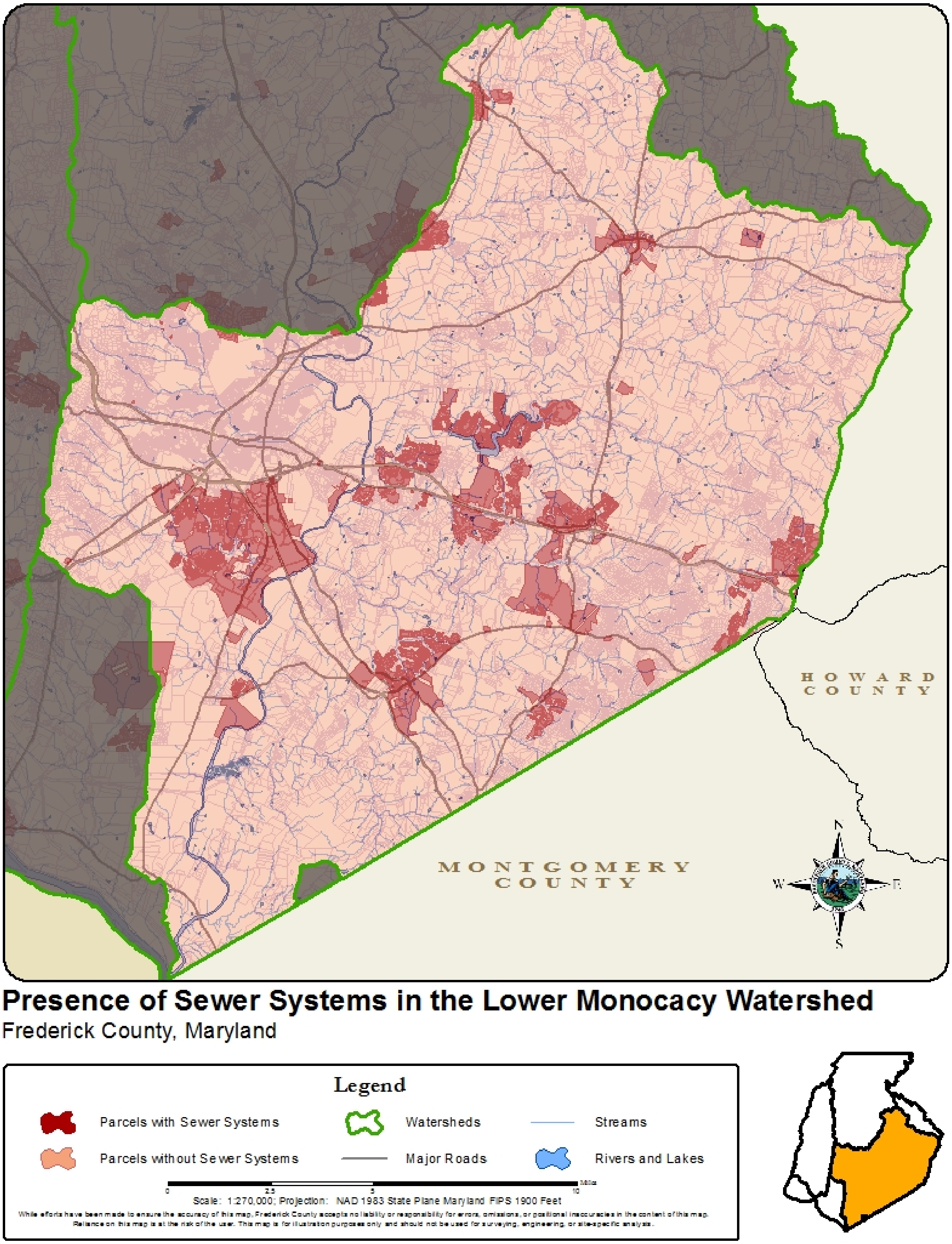


Figure 19: Sanitary Sewershed in the Lower Monocacy Watershed

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 41: MPR Percent Derivation for Lower Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	2,652.4	76.06%
Domestic	75%	3,900.4	
Wildlife	0%	606.4	
Livestock	75%	0	

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the revised Watershed Treatment Model per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in Table 42 and Table 43. Detail on the amount of treatment modeled in each scenario is provided in Appendix 18.

Table 42: Cumulative restoration treatment

	Total Restoration (ac except as noted)		
BMP Type	**IA**	**Pervious**	**DA**
Bioretention	96.05	187.10	283.15
Dry Swale	25.20	40.80	66.00
Filters	7.24	2.60	9.84
Grass Channel	0.30	0.97	1.27
Infiltration	0.00	0.00	0.00
Wet Pond	1,051.21	2,221.63	3,272.84
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	85,433.80
Tree Planting	0.00	450.31	450.31
Riparian Buffer	0.00	208.94	208.94

Table 43: Cumulative restoration treatment for alternative bacteria BMPs

Alternative BMPs	Total Restoration	
Pet Waste Education	2,648	households
Street Sweeping	0	
Impervious Disconnection	0	
Land Use Change – Vacant to Forest	491	acres
Illicit Connection Removal	0%	remediated
SSO Repairs	0%	remediated
Septic System Pumping	3,400	systems
Septic System Repair	22	systems
Septic System Upgrade	84	systems
Septic System Retirement	6	systems

Table 44 shows the calibrated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 20.

Table 44: Reductions by Scenario for Lower Monocacy Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	290,920	290,920	4,423,422	14.5%	17.6%
Complete	92,215	92,215	4,622,127	4.6%	5.6%
Programmed	139,798	232,013	4,482,329	11.6%	14.1%
Identified	762,996	995,010	3,719,333	49.6%	60.4%
Potential	1,021,746	2,016,755	2,697,587	100.6%	122.3%
Calibrated Required BST WLA Reduction		2,004,916			
Calibrated Required BST MPR Reduction		1,648,58			

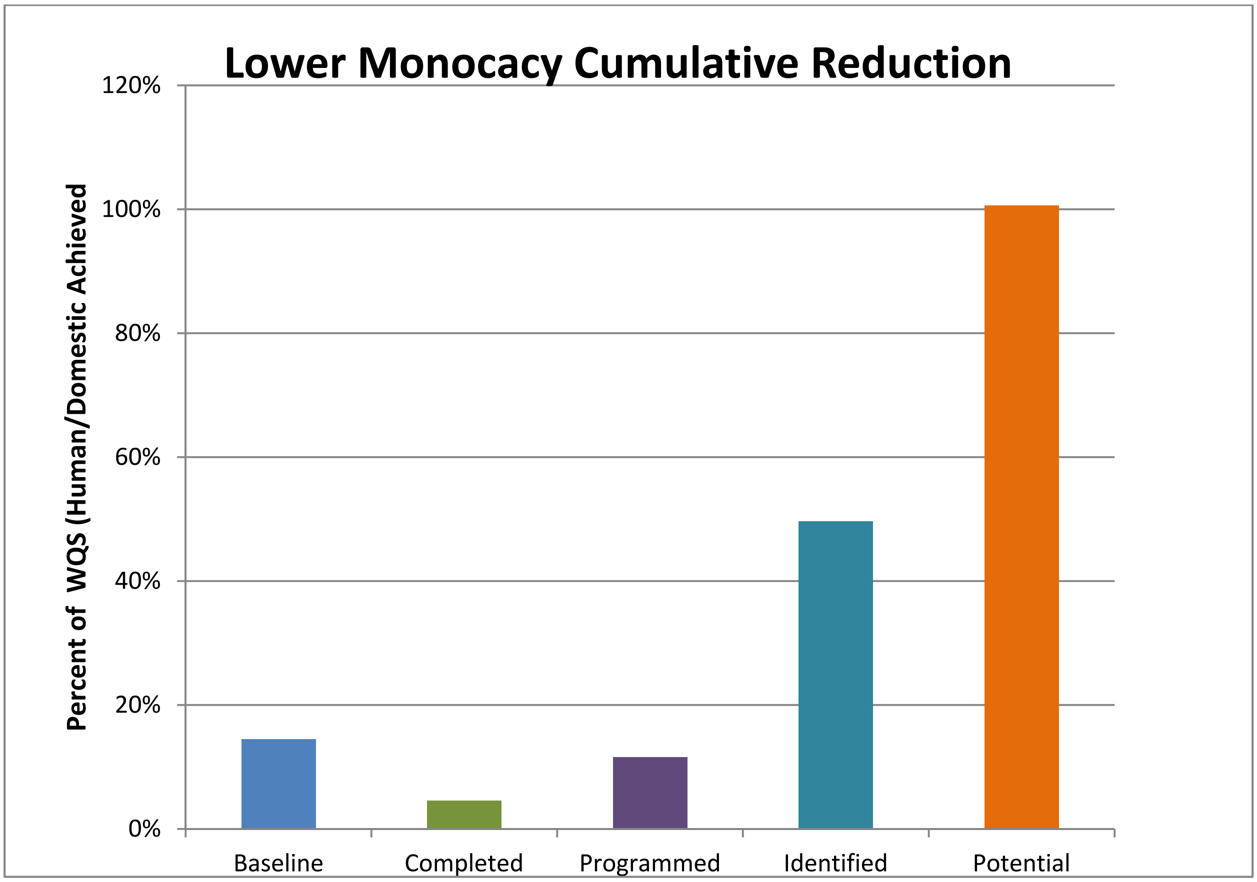


Figure 20: Lower Monocacy Cumulative Reduction (Percent of SW-WLA)

Both the MPR and the SW-WLA are met with the potential tier of treatment. The approach for this TMDL will be to work towards Adaptive Management. The initial focus will be on the most effective measures which remediate human sources of bacteria first, implementing structural BMPs which will treat phosphorus and sediment along with bacteria, and monitoring the results to determine if additional treatment will be necessary.

UPPER MONOCACY WATERSHED

MDE completed monitoring of the Upper Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the mainstream Upper Monocacy River, portions of tributaries Toms Creek and Piney Creek, and the tributary Double Pipe Creek are designated Use IV-P water bodies (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). Use III-P (Water Contact Recreation, Protection of Aquatic Life, Non-tidal Cold Water and Public Water Supply) is designated to the remaining tributaries in MD, which are Tuscarora Creek, Fishing Creek, Hunting Creek, and Owens Creek.

MDE developed a TMDL for *E. coli* in the Upper Monocacy in 2009 (MDE UM 2009) which was approved by EPA in 2009. The portion of the Upper Monocacy watershed that is in Frederick County is mostly rural, with its main stormwater inputs from roads and rural residences. There are 101.3 miles of sanitary sewer lines in this portion of the watershed, and 33% of dwelling units are unsewered. Bacterial Source Tracking monitoring was conducted once a month for a year (total of 12 times) at nine MDE monitoring stations in the Upper Monocacy watershed. Two additional stations were used to determine the loadings coming from Double Pipe Creek.

To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL (MDE UM 2009) are shown in the graph below.

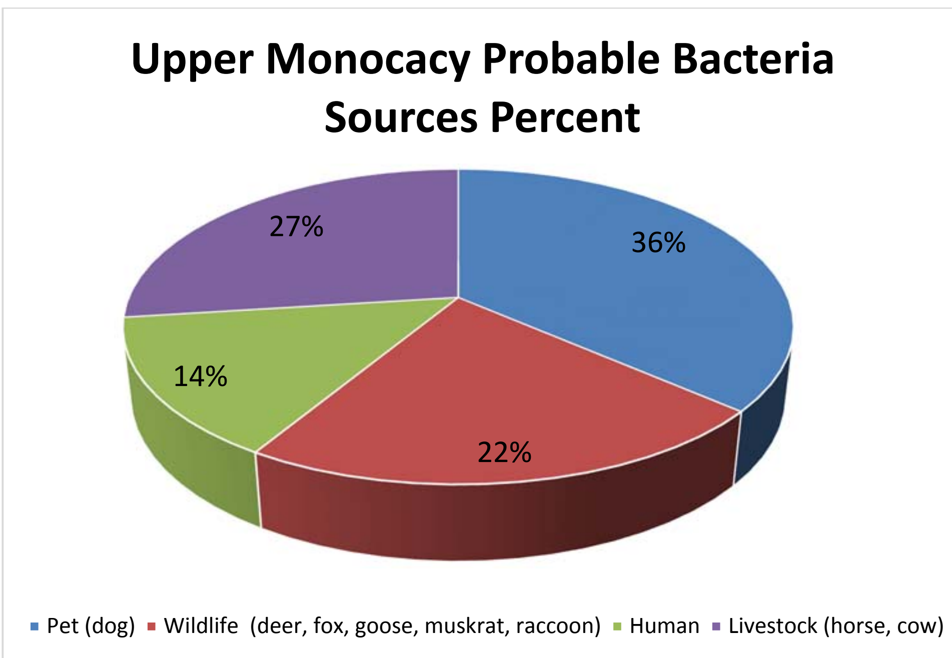


Figure 21: Upper Monocacy Probable Bacteria Sources Present

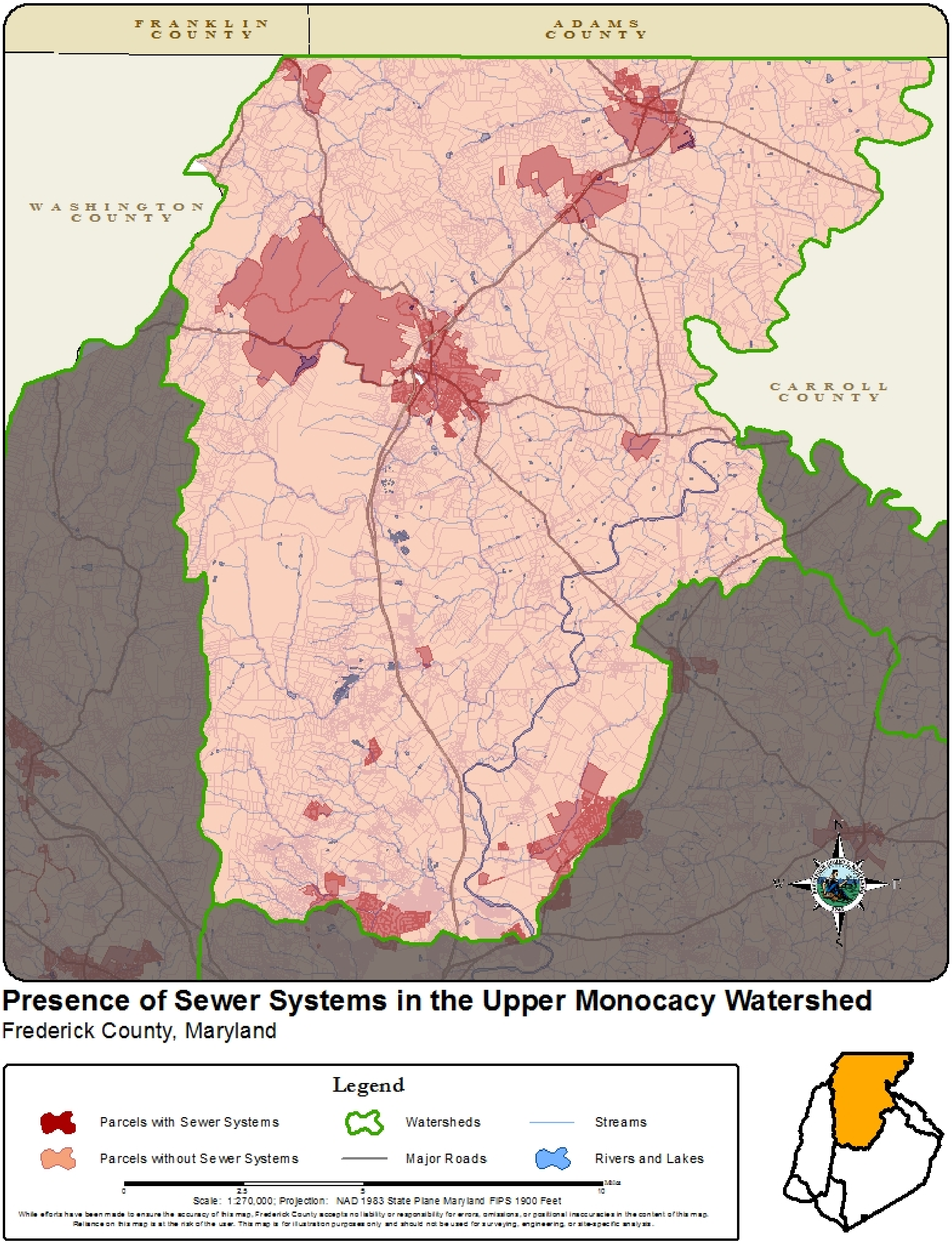


Figure 22: Sanitary Sewershed in the Upper Monocacy River Watershed

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 45: MPR Percent Derivation for Upper Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	3,368.2	85.3%
Domestic	75%	943.5	
Wildlife	0%	267.6	
Livestock	75%	0	

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the WTM per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in Table 46 and

	Total Restoration (ac except as noted)		
BMP Type	IA	Pervious	DA
Bioretention	27.75	27.75	55.50
Dry Swale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	96.83	233.28	330.11
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	16,661.50
Tree Planting	0.00	107.51	107.51
Riparian Buffer	0.00	38.11	38.11

Table 47: Cumulative restoration treatment for alternative bacteria BMPs

Alternative BMPs	Total	
Pet Waste Education	600	households
Street Sweeping	0	
Impervious Disconnection	0	
Land Use Change – Vacant to Forest	88	acres
Illicit Connection Removal	0%	remediated
SSO Repairs	100%	remediated
Septic System Education	1,658	systems
Septic System Repair	32	systems
Septic System Upgrade	84	systems
Septic System Retirement	1	systems

Detail on the amount of treatment modeled in each scenario is provided in Appendix 19.

Table 46: Cumulative restoration treatment

BMP Type	Total Restoration (ac except as noted) IA	Pervious	DA
Bioretention	27.75	27.75	55.50
Dry Swale	0.00	0.00	0.00
Filters	0.00	0.00	0.00
Grass Channel	0.00	0.00	0.00
Infiltration	0.00	0.00	0.00
Wet Pond	96.83	233.28	330.11
Wetland	0.00	0.00	0.00
Streams (LF)	0.00	0.00	16,661.50
Tree Planting	0.00	107.51	107.51
Riparian Buffer	0.00	38.11	38.11

Table 47: Cumulative restoration treatment for alternative bacteria BMPs

Alternative BMPs	Total Restoration	
Pet Waste Education	600	households
Street Sweeping	0	
Impervious Disconnection	0	
Land Use Change – Vacant to Forest	88	acres
Illicit Connection Removal	0%	remediated
SSO Repairs	100%	remediated
Septic System Education	1,658	systems
Septic System Repair	32	systems
Septic System Upgrade	84	systems
Septic System Retirement	1	systems

Table 48 shows the calibrated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in Figure 23.

Table 48: Reductions by Scenario for Upper Monocacy Bacteria TMDL (bn MPN/yr)

Scenario	Scenario Reduction	Cumulative Reduction	Load	% of Reqd Reduction	% of MPR Reduction
Baseline	77,016	77,016	1,136,894	14.0%	15.9%
Complete	12,173	12,173	1,201,737	2.2%	2.5%
Programmed	23,635	35,808	1,178,102	6.5%	7.4%
Identified	250,800	286,608	927,301	52.0%	59.1%
Potential	279,556	566,164	647,745	**102.7%**	**116.7%**
Calibrated Required BST WLA Reduction		551,393			
Calibrated Required BST MPR Reduction		485,043			

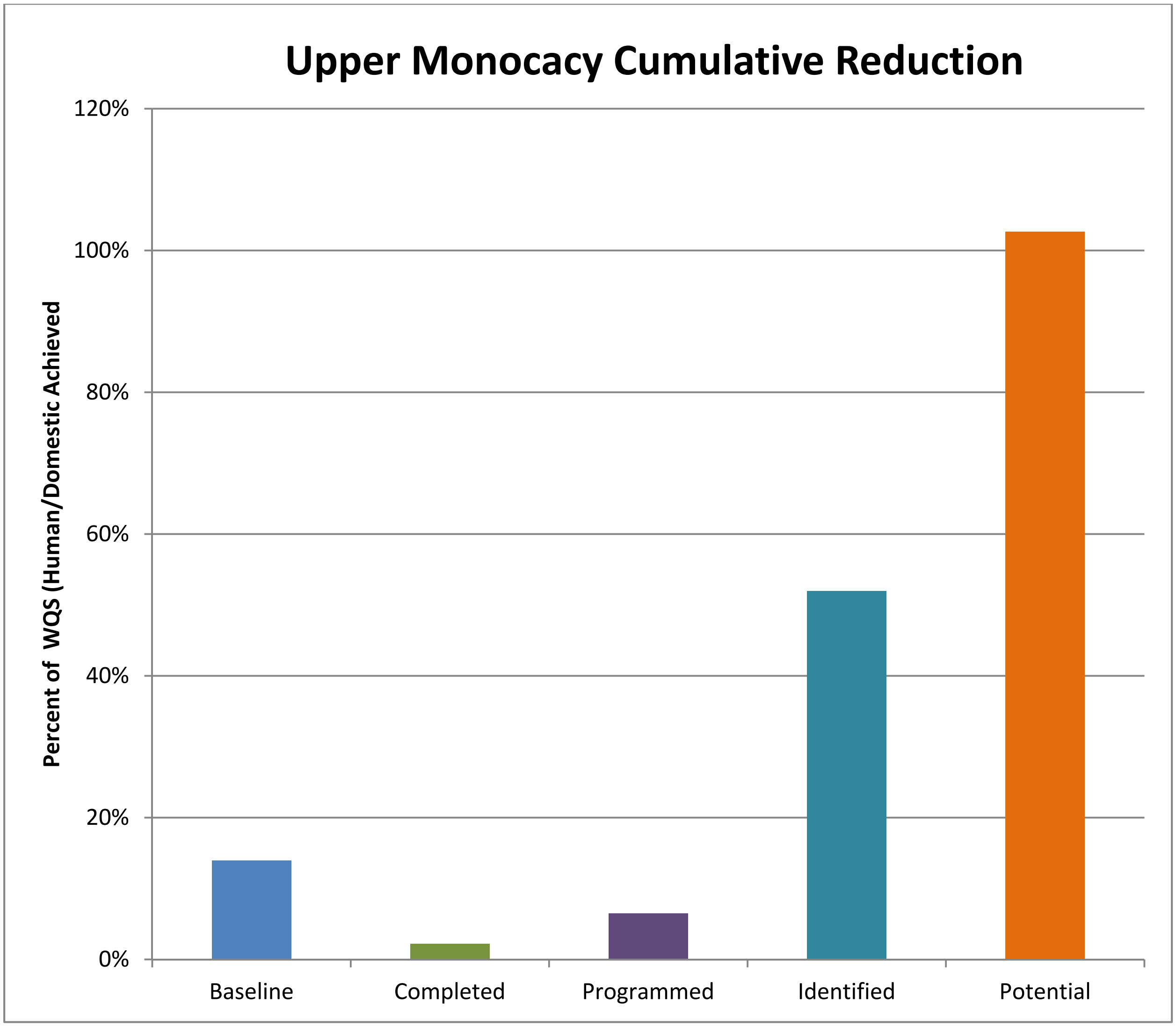


Figure 23: Upper Monocacy Cumulative Reduction in Percent of SW-WLA

Both the MPR and the SW-WLA are met with the proposed treatment. The County's approach for this TMDL will be to work towards Adaptive Management. The initial focus will be on the most effective measures which remediate human sources of bacteria first, implementing structural BMPs which will treat phosphorus and sediment along with bacteria, and monitoring the results to determine if additional treatment will be necessary.

MONITORING AND EVALUATION

With Hood College and the Chesapeake Bay Foundation, the County selected sites for *E. coli* testing in Summer 2016. The chosen sites were based on areas with suspect septic tank locations as determined by the Health Department and other areas of potential and confirmed high counts of bacteria. CBF published the Frederick County data at http://www.cbf.org/issues/polluted-runoff/rainfall-revelations/2016-bacteria-testing-maryland-data.html. A map of sampling sites and 2016 data are shown below:

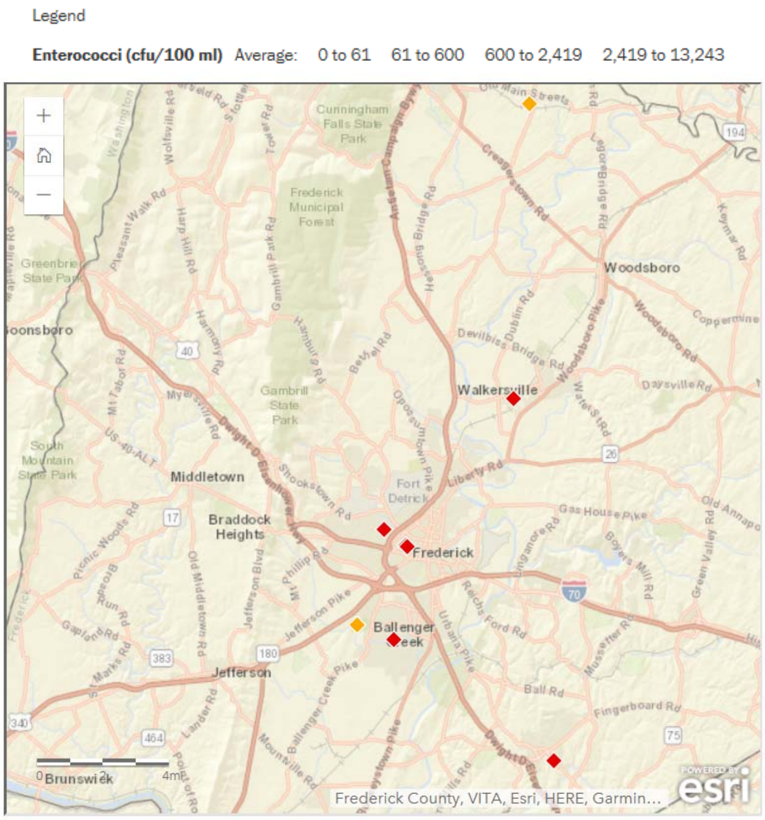


Figure 24: *E. Coli* Sampling Sites

Table 49: 2016 *E. coli* Sampling Results

2016 Water Sampling Data - MD (enterococci bacteria)	14-Jun	16-Jun	23-Jun	27-Jun	5-Jul	11-Jul	8-Aug	16-Aug
Ballenger Creek - Ballenger Creek Park	308	8,100	2,000	280	1,100	230	324	394
Ballenger Creek - BC Elementary School	400	16,400	2,300	515	3,600	663	1,840	2,000
Carroll Creek - Frederick City	620	14,680	8,000	340	2,200	460	930	161
Glade Run - Walkersville	3,200	19,800	3,900	2,500	2,325	920	650	
Merryvale Creek - Frederick City	2,120	4,800	4,700	4,800	4,800	1,640	1,720	5,050
Owens Creek - Loys Station Park	840	6,400	3,200	560	2,050	1,005	1,070	
Peter Pan Run - Urbana	240	3,680	2,400	260	13,300	450	1,762	372
Rock Creek - Frederick City	1,120	16,300	8,350	630	2,500	1,040	1,482	400

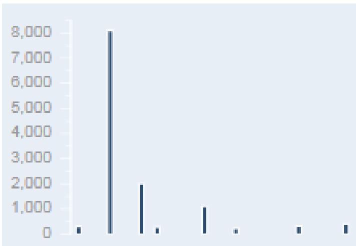
Key

Red values	= Enterococci bacteria counts greater than 61 cfu/100 ml in fresh water. At the time of sampling the site was not healthy for "moderate" bathing use, according to EPA standards. Readings above 151 cfu are not suitable for any bathing or "full body contact." More on the EPA standards.
Red values	(underlined and italicized) = Enterococci bacteria counts greater than the 2,419 maximum detection limit for analysis performed that day.
Light blue background	= .5 inches or more of rainfall at least 24 hours before collecting water samples

IN 2018, Frederick County received a draft publication from MDE that contained proposed monitoring requirements for the next NPDES MS4 permit. Staff circulated this for review by KCI and compiled comments, which were submitted back to MDE.

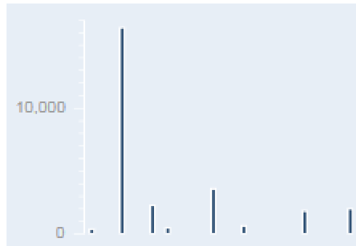
Ballenger Creek - Ballenger Creek Park

Average Enterococci Levels
All Samples: 1,592.00 cfu/100ml
Wet Weather: 2,899.00 cfu/100ml
Dry Weather: 286.00 cfu/100ml



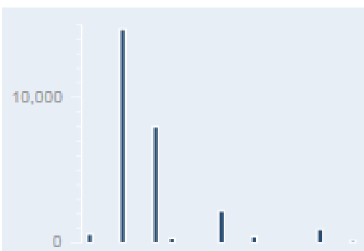
Ballenger Creek - BC Elementary School

Average Enterococci Levels
All Samples: 3,465.00 cfu/100ml
Wet Weather: 6,075.00 cfu/100ml
Dry Weather: 855.00 cfu/100ml



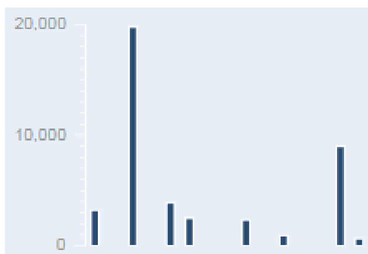
Carroll Creek - Frederick City

Average Enterococci Levels
All Samples: 3,424.00 cfu/100ml
Wet Weather: 6,260.00 cfu/100ml
Dry Weather: 588.00 cfu/100ml



Glade Run - Walkersville

Average Enterococci Levels
All Samples: 4,756.00 cfu/100ml
Wet Weather: 8,675.00 cfu/100ml
Dry Weather: 1,818.00 cfu/100ml

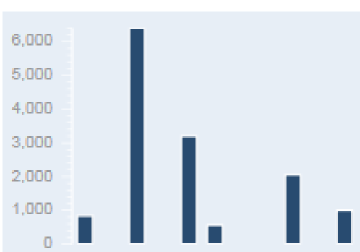


Merryvale Creek - Frederick City

Average Enterococci Levels
All Samples: 3,704.00 cfu/100ml
Wet Weather: 4,838.00 cfu/100ml
Dry Weather: 2,570.00 cfu/100ml

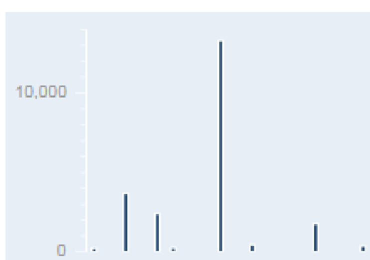
Owens Creek - Loys Station Park

Average Enterococci Levels
All Samples: 2,161.00 cfu/100ml
Wet Weather: 3,883.00 cfu/100ml
Dry Weather: 869.00 cfu/100ml



Peter Pan Run - Urbana

Average Enterococci Levels
All Samples: 2,808.00 cfu/100ml
Wet Weather: 4,938.00 cfu/100ml
Dry Weather: 678.00 cfu/100ml



Rock Creek - Frederick City

Average Enterococci Levels
All Samples: 3,970.00 cfu/100ml
Wet Weather: 6,888.00 cfu/100ml
Dry Weather: 1,053.00 cfu/100ml

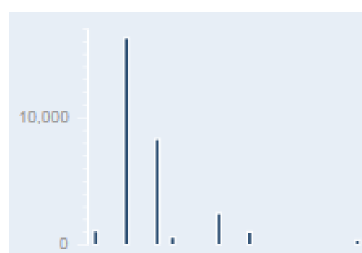


Figure 25: 2016 *E. Coli* Sampling Results

BACTERIA CONCLUSION

For all three *E. Coli* TMDLs, the SW-WLAs and MPRs could be met at the completion of the Potential Tier projects. All three restoration plans relied on remediating human sources of bacteria by 100% through elimination of SSOs, repair of all failing septic systems, identification of leaking sewers, and/or cross-connections through the IDDE program.

All watersheds used a multi-pronged approach that included volumetric practices for stormwater such as bioswales and pond retrofits, as well as alternative BMP practices including riparian buffer expansion and tree planting that also contribute to reductions in nutrient and sediment TMDLs. Outreach programs for pet waste management and septic system maintenance were also proposed.

SUMMARY PROJECTS, COSTS AND TIMEFRAMES FOR ALL PLANS

Point of Rocks Stream Restoration Project

METHODS

This section provides an estimate of the cost of implementing both the Impervious Cover Restoration Plan and TMDL Restoration Plans to meet the stated goals. It is important to note that the costs represent planning level estimates for use in high level forecast budgeting with many assumptions made. The cost estimates provided here focus on the capital costs associated with implementing the projects described in previous sections. The following presents the methods used to derive the cost estimates per project type with summaries of costs for full implementation at the watershed and County scale.

PROJECTS BY RESTORATION TIER

Figure 26: Restoration Tiers

As stated earlier in this document, Restoration Tiers include **Baseline**, **Completed**, **Programmed**, **Identified**, and **Potential** scenarios. Baselines are the TMDL loads without restoration Best Management Practices. Completed projects were finished after March 11, 2007, the expiration date of the previous permit and by June 30, 2019, the current reporting period. Programmed projects are programmed into the County's Capital Improvement Program and other programs and have funding and schedules. A subset of these projects will be completed during the permit term, which is set to expire December 29, 2019. The rest will be complete by 6/30/2023. Identified projects can be found in Watershed Management Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government and its partners and consultants to identify watershed restoration opportunities. They are not yet funded or scheduled as individual projects, though they may have proposed CIP funds in aggregate. They will be completed by 6/30/2025. Potential Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land and will finish between June 30, 2025 and June 30, 2052.

SOURCES FOR COST ESTIMATES

Cost estimates for structural BMPs come from the following sources:

- **Completed** CIP project costs are used where available. When completed costs are not available, Brown and Caldwell's 2014 *Technical Memo 1* (B&C 2014) is used. This study was prepared under contract to AquaLaw, Frederick County's outside legal counsel on stormwater matters, as part of a review of the County's MEP Analysis. (B&C 2014). Brown and Caldwell made recommendations on costs based on The King and Hagan study (2011) and adjusted dollars of some practices based on their experience with contracting projects in Maryland. They also adjusted cost estimates to FY17 as the midpoint of the permit.
- **Programmed** and **Identified** estimates come from the proposed CIP budget. These represent engineering cost estimates at a 10-30% design phase. Tree planting and easement acquisition program costs come from information on County reforestation projects.
- **Potential** scenarios use costs derived as described below.

Cost estimates for operational BMPs have been derived from these sources described below.

- Management program costs for *E. coli* are absorbed by the operating budget for the NPDES MS4 permit.
- Costs for denitrification systems are taken from the Bay Restoration Fund and are estimated at $13,800 per system (personal communication by email with Kristin Mielcarek on 1/13/2015).
- Costs for septic upgrades to sewer are estimated from Anne Arundel County (URS ESA 2016) at $50,000.

Costs not included are pre- and post-construction monitoring and operational costs such as additional County staff to manage the work, conduct inspections, enforcement, or maintenance, and similar activities. These costs will be developed in future planning stages and factored into the County's budgeting.

COST ESTIMATING PROCEDURE FOR POTENTIAL PROJECTS

The County's recent history with restoration projects and preparation of the Capital Improvement Plan (CIP) have been the basis for project costs for potential projects where siting and concept design have not yet been undertaken. For the restoration BMPs proposed, direct costs were estimate for construction, then the following indirect and other costs were estimated based on a pro-rated amount of the construction cost:

- Contingency
- Design
- Inspection
- Project Management
- Site Improvement
- Net Present Value of Operations and Maintenance

For each project, a typical size was used from B&C (2014) and a project cost was derived (see Table 50. The number of projects proposed in the Potential tier, multiplied by the project cost, gave the estimated cost for these projects, also shown in Table 50.

Table 50: Potential Tier Project Costs)

BMP Type	Project Size	Unit	Per Unit Costs				Total Cost per Project
			Direct Construction and Contingency	Design and Indirect Costs	Land Acquisition	20-Yr PV O&M Cost	
Stormwater Pond Retrofit	20	IA	$24,200.00	$12,452	$0	$763	$748,300
Bioretention	10	IA	$82,500.00	$42,450	$10,000	$1,862	$1,278,120
New Stormwater Pond	20	IA	$49,500.00	$25,470	$10,000	$763	$1,524,660
Forest Buffer	2	IA	$32,050.00	$1,603	$10,000	$5,475	$88,255
Stream Restoration	1200	LF	$440.00	$226	$50,000	$15	$867,500

Potential projects have been identified by determining the level of treatment required to meet the pollutant load reduction for each of the local TMDLs.

TIMEFRAME ESTIMATES

Timeframes for the plan are based on the following by Restoration Tier:

- **Baseline:** reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL or impervious surface goal was established (2000/2005 for sediment TMDLs; 2009 for phosphorus TMDLs; 2010 for nitrogen and phosphorus in the Bay; and 2004 for *E. coli* TMDLs). In the case of the Impervious Cover Restoration Plan, the baseline is the end date of the previous MS4 permit, March 11, 2007.
- **Completed:** Completed between the baseline date and June 30, 2019, the end of the reporting period for this Restoration Plan.
- **Programmed:** Funded and scheduled projects that are funded and scheduled to be completed after July 1, 2019. The subset used in the Impervious Cover Restoration Plan is scheduled to be completed before December 29, 2019.
- The **Identified** timeframe for completion begins December 29, 2019, and ends when the currently identified projects are completed, on or before 6/30/2025.
- The **Potential** timeframe begins when the last **Identified** project is completed on 6/30/2025 and goes on until all projects required to meet all TMDLs have been implemented on 6/30/2052.

As part of its *Technical Memorandum No. 1: Report on Frederick County Data Review Findings* (2014), Brown and Caldwell provided timeframe estimates per project type per phase based on its experience managing public procurement contracts in the state of Maryland. These project phases are used to determine the length of project phases in the **Identified** and **Potential** Restoration Tiers.

COMPLETED, PROGRAMMED AND IDENTIFIED PROJECTS, BUDGETS AND TIMEFRAMES

103 **Completed** projects are included in Appendix 1. Estimated budget for the 163 completed projects and budgets through June 30, 2019 are $35,423,116, based on the County's Financial Assurance Plan as reflected in Table 53. These BMPs were completed between March 11, 2007 and June 30, 2019.

Programmed projects are budgeted into the programmed five-year Capital Improvement Program based on engineering cost estimates. Table 53 includes a $28,645,667 budget for the Programmed Scenario. These projects are to be completed by June 30, 2023. There are also **Identified** projects in this budget estimate where the projects are coming from a pooled fund to be completed by FY23 but have not yet been disaggregated as separate projects.

Municipal and Financial Services Group (MFSG) was hired by the County's legal counsel, AquaLaw, PLC to "review cost data and timeframes used by the County to estimate and project the financial impact on customers to implement 20% impervious surface restoration requirements anticipated in the upcoming permit reissuance." (MFSG 2014). From an analysis of stormwater remediation fees across the country. MFSG determined that the County should escalate its total fiscal year 2015 budget 15% to include Operating and Capital per year for each year of the permit. The MS4's Programmed CIP costs generally follow this guidance.

As seen in Appendix 2, costs in FY19 dollars for the 109 projects in the five year permit Capital Improvement Project Budget and other projects are **$38,316,922** Table 51 shows operating and capital expenditures by funding source. The table was prepared for the County's Financial Assurance Plan.

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Table 51: Projected annual and 5-year costs to meet the impervious surface restoration plan requirements

DESCRIPTION	PAST UP THRU FY17	CURRENT YEAR FY18	PROJECTED YEAR 1 FY19	PROJECTED YEAR 2 FY20	PROJECTED YEAR 3 FY21	PROJECTED YEAR 4 FY22	PROJECTED YEAR 5 FY23	TOTAL COSTS
Operating Expenditures (costs)								
Street Sweeping Program	$301,888	$23,591	$42,035	$43,086	$44,379	$45,710	$47,081	$410,600
Inlet Cleaning	$0	$0	$0	$0	$0	$0	$0	$0
Septic Pumpout Rebate	$0	$25,000	$25,000	$25,000	$0	$0	$0	$75,000
Support of Capital Projects[1]	$738,283	$104,302	$357,551	$570,728	$368,278	$379,326	$390,706	$1,770,864
Debt Service Payment	$19,414	$59,620	$262,974	$263,043	$263,054	$262,985	$263,047	$605,051
Capital Expenditures (costs)								
General Fund (Paygo)[2]	$9,104,358	$3,661,951	$3,018,599	$3,181,950	$2,635,000	$1,220,000	$2,220,000	$18,966,858
WPR Fund (Paygo)	$0	$0	$0	$0	$0	$0	$0	$0
Debt Service[3]	$2,611,805	$4,750,000	$5,092,000	$3,863,449	$3,403,846	$4,817,500	$3,817,500	$16,317,254
Grants & Partnerships[4]	$3,433,200	$424,700	$1,366,845	$130,000	$130,000	$130,000	$130,000	$5,354,745
Other (please stipulate capital expenditure)*	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal operation and paygo:	$10,163,943	$3,874,464	$3,706,159	$4,083,807	$3,310,711	$1,908,020	$2,920,834	$29,967,937
Total expenditures:	$16,208,948	$9,049,164	$10,165,004	$8,077,256	$6,844,557	$6,855,520	$6,868,334	$64,068,782
Total ISRP costs except debt service:								**$63,463,732**
Compare ISRP costs (except debt service) / total ISRP proposed actions:								**106%**

1 Table data from revised 6/28/2019 FAP.
2 Support of Capital Project equals Assessments + CIP operating budget impacts
3 General Fund Paygo – FY19 to FY23 estimates are from approved FY20 CIP. Future years after FY20 subject to approvals.
4 Estimates provided by Finance Division
5 Other Septic Denitrification from BRF Grant goes to Canaan Valley Institute. Grants for BRF estimated at $130K beginning FY20 due to diminishing fund
6 The "Compare ISRP costs" number cannot be 100% for the following reasons: the ISRP Cost 4-202.1(j)(1)(i)2 spreadsheet Operating Support of Capital Projects like watershed assessments and O&M and the All Actions 4-202.1(j)(i)1 spreadsheet does not. The CIP costs in the All Actions spreadsheet are grouped by completion year where the ISRP Cost spreadsheet shows costs by year. The CIP budgets are in multiyear phases where the ISRP Cost and Spec Actions tabs roll up all costs into one year.

IDENTIFIED PROJECTS, COSTS AND TIMEFRAMES

Identified projects were compiled from existing planning documents. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They will be completed by June 30, 2025. Some are included in the proposed CIP in Table 53 as funds for projects to be awarded by FY23. The studies used to develop the Identified scenario tier are listed below. Full bibliographies are in the References section.

- Upper Monocacy River WRAS, (Schultz et al. 2008)
- Lower Monocacy River WRAS, (Schultz and Moore, 2004)
- An Assessment of Stream Restoration and Stormwater Management Retrofit Opportunities in Lower Bush Creek Watershed, completed in August 2003 (Perot, Morris et al., 2003)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Ballenger Creek Watershed, completed August 2005 (Perot, Morris et al., 2005)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, completed June 2006 (Perot, Morris et al., 2006)
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, completed April 2009 (Stribling et al., 2009).
- Final Report Watershed Assessment of Ballenger Creek, completed January 2001 (Roth et al., 2001a)
- Watershed Assessment of Lower Bush Creek, completed March 2001 (Roth et al., 2001b)
- Watershed Assessment of Lower Linganore Creek, completed in June 2002 (Perot, Morris et al., 2002)
- Bennett Creek Watershed Assessment, completed March 2008 (Stribling et al., 2008)
- Upper Monocacy Watershed Assessment
- Lower Monocacy Watershed Assessment
- Ballenger Creek Stormwater Master Plan
- Little Hunting Creek Watershed Assessment and Restoration Concept Report
- County-owned Stormwater Management Best Practices Retrofit Assessment, and
- Point of Rocks Storm Drain Analysis
- Potomac River Direct Watershed Study (May 2019)
- Catoctin Creek Watershed Study (May 2019)
- Double Pipe Creek Watershed Study (May 2019)

This scenario includes 23 projects consisting of tree planting, stream restoration, and new wet ponds and retrofits at a cost of $14,316,994. At current funding projections, this scenario would require about 6.0 years to complete. Identified projects are in Appendix 3.

POTENTIAL PROJECTS, COSTS AND TIMEFRAMES

The **Potential** tier has been defined by the level of treatment rather than project by project. An estimated number of projects has been derived based on average area treated or length of stream restoration for past County projects. Using this factor, along with the amount of treatment proposed, gives a total of 180.55 projects (Table 52), split among pond retrofits, bioretention, stream restoration, and riparian buffers. A summary of potential projects which would assist the County in meeting its targeted TMDL goals is shown in Appendix 4 for each watershed.

Table 52: Number of Projects and Cost Estimate for Potential Tier

BMP Type	No of Projects	Cost per Project	Total Cost
Bioretention	9.00	$1,278,120	$11,503,080
Bioswale	2.00	$1,278,120	$2,556,240
Wet Pond Retrofit	42.00	$748,300	$31,428,600
Stream Restoration	82.30	$867,500	$71,395,250
Riparian Buffer	45.25	$88,255	$3,993,539
	180.55		**$120,876,709**

Project costs and funding for the **Potential** tier set the timeline for meeting each of the local TMDLs. The following plan has been developed to optimize completion of TMDLs with lower requirements first, while continuing to implement projects for the more intensive TMDLs. The plan is based on an average funding level of $4.5MM per year. Funding from FY20 to FY22 is earmarked for Programmed and Identified projects; therefor the start date for **Potential** projects, with the exception of Double Pipe Creek, is the beginning of FY25. Results of the analysis through FY35 are shown in Table 53. When funded at this level, the sediment, bacteria, and phosphorus TMDLs for Lower Monocacy will be met in 2042, 2048, and 2052 respectively.

Table 53: Potential Tier Funding Timeline through FY40 (in $000)

	Fiscal Year	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total per Year
Total Potential Cost		$16,838	$721	$92,941	$0	$10,377	$120,877
Forecast Completion		**2033**	**2025**	**2052**	**n/a**	**2033**	$4,499
	FY26	$2,105		$1,100		$1,297	$4,502
	FY27	$2,105		$1,100		$1,297	$4,502
	FY28	$2,105		$1,100		$1,297	$4,502
	FY29	$2,105		$1,100		$1,297	$4,502
	FY30	$2,105		$1,100		$1,297	$4,502
	FY31	$2,105		$1,100		$1,297	$4,502
	FY32	$2,105		$1,100		$1,297	$4,502
	FY33	$2,105		$1,100		$1,297	$4,502
	FY34			$4,500			$4,500
	FY35			$4,500			$4,500

Projects that treat sediment also treat phosphorus and to some extent, *E. coli*. As can be seen in Table 1 and Figure 3, in general, in watersheds with TMDLs for these pollutants, if the sediment targets are met, they will be overtreated for other impairments. Because of the nested nature of projects to treat different TMDLs in the same watershed, it was not feasible to determine which of the **Potential** tier projects would be applicable to which pollutant. As a first approximation of determining end dates for the phosphorus and *E. coli* TMDLs, the duration to meet these TMDLs was pro-rated by the amount of overtreatment, shown in Table 54. This analysis will be revisited in subsequent Restoration Plans to develop an estimated completion based on project implementation.

Table 54: Summary of TMDL completion for Sediment, Phosphorus, and *E. Coli* TMDLS

	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy
Pollutant	Sediment	Phosphorus	Phosphorus	Sediment	Sediment
Beginning Year	2020	2022	2020	2020	2021
Completion Year	**2033**	**2025**	**2052**	**2022**	**2033**
Years to Complete	13	3	32	2	12
Pollutant	Sediment	Phosphorus	Phosphorus	--	Sediment
Years to Complete	7	1	22	--	3
Completion Year	**2027**	**2023**	**2042**	**--**	**2024**
Pollutant	--	*E. Coli*	*E. Coli*	--	*E. Coli*
Years to Complete	--	1	2	--	4
Completion Year	--	**2028**	**2048**	--	**2030**

CONCLUSION

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. The Plan will take a cumulative 33 years from the date of this report to address TMDL requirements, and will cost a cumulative amount of $179,389,137. The Restoration Plan also meets TMDL pollutant removal targets for all 12 local TMDL as shown in Table 55.

Table 55: Local TMDL Pollutant Load Percent Reductions by Watershed

Watershed	MDE Published Reduction	Bacteria Reduction Human / Domestic	County Planned Reduction	% of Goal Achieved	Completion Date
Catoctin Creek TP	11.0%		23.5%	213.5	2027
Catoctin Creek TSS	49.1%		49.2%	100.1%	2033
Double Pipe Creek EC	98.8%	56.3%	57.2%	101.6%	2028
Double Pipe Creek TP	73.0%		76.1%	104.3%	2025
Double Pipe Creek TSS	46.8%		209.9%	448.6%	2023
Lower Monocacy River EC	92.5%	45.3%	45.6%	101.6%	2048
Lower Monocacy River TP	28.0%		28.0%	100.0%	2052
Lower Monocacy River TSS	60.8%		88.6%	145.7%	2042
Potomac River Montgomery Co. TSS[1]	36.2%		--	--	--
Upper Monocacy River EC	97.0%	48.5%	49.8%	102.7%	2030
Upper Monocacy River TP	4.0%		16.1%	401.8%	2024
Upper Monocacy River TSS	49.0%		49.0%	100.1%	2033
(1) MDP Land use shows no urban area in County portion of this watershed. Baseline load modeling will be reviewed in the future with any updates from Phase 6 CBWM					

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APPENDIX 1: COMPLETED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

Specific actions and expenditures that the county or municipality implemented in prior fiscal years to meet its impervious surface restoration plan requirements. Data includes capital projects completed as of June 30, 2019.

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	NPDES PROGRAM COST	YEAR
Description	REST BMP TYPE	BMP CLASS	IMP ACRES	IMPL COST	IMPL COMP YR
	VSS	A	13.36	$ 38,081	2015
	VSS	A	21.84	$ 42,153	2016
	VSS	A	18.83	$ 34,956	2017
	VSS	A	11.20	$ 23,591	2018
	VSS	A	20.55	$ 31,016	2019
	SEPC	A	2.73	$ 350,000	2007
	SEPD	A	2.60	$ 138,000	2008
	SEPD	A	4.94	$ 262,200	2009
	SEPD	A	0.78	$ 41,400	2010
	SEPD	A	2.60	$ 138,000	2011
	SEPD	A	4.16	$ 220,800	2012
	SEPD	A	10.92	$ 579,600	2013
	SEPD	A	7.54	$ 400,200	2014
	SEPD	A	9.10	$ 483,000	2015
	SEPD	A	5.20	$ 276,000	2016
	SEPD	A	6.76	$ 414,000	2017
	SEPD	A	2.08	$ 257,000	2018
	SEPD	A	5.20	$ 287,000	2019
	SEPP	A	9.39	$ 101,725	2015
	SEPP	A	21.00	$ 227,500	2016
	SEPP	A	33.78	$ 365,950	2017
	SEPP	A	54.84	$ 594,100	2018
	SEPP	A	68.13	$ 738,075	2019
Ballenger Creek Elementary School - Urban Forest Buffer	FPU	A	0.58	$ 19,140	2007
Orchard Grove Elementary School - Tree Planting	FPU	A	0.32	$ 10,560	2013
Old National Pike Park - Riparian Forest Buffer	FPU	A	1.83	$ 60,390	2011
Deer Crossing Elementary School - Tree Planting	FPU	A	1.09	$ 35,970	2013
Windsor Knolls Middle School - Urban Forest Buffer	FPU	A	3.29	$ 75,240	2011

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	NPDES PROGRAM COST	YEAR
Windsor Knolls Middle School - Tree Planting	FPU	A	1.41	$ 75,240	2011
Worthington Manor Golf Course - Urban Forest Buffer	FPU	A	3.47	$ 114,511	2011
Urbana Community Park - Riparian Forest Buffers (previously cropped, LU conversion)	FPU	A	0.90	$ 29,700	2009
Wolfsville Elementary School - Tree Planting	FPU	A	0.41	$ 13,530	2010
Urbana High School - Tree Planting	FPU	A	0.15	$ 4,927	2009
Urbana Middle School - Tree Planting	FPU	A	0.46	$ 15,180	2009
New Market Middle School - Tree Planting	FPU	A	1.22	$ 40,260	2012
Holly Hills HOA - Urban Forest Buffer	FPU	A	0.44	$ 14,520	2007
Englandtowne Retrofit Project Tree Planting	FPU	A	0.28	$ 18,787	2015
Middletown High School - Tree Planting	FPU	A	0.24	$ 7,908	2009
Beaver Dam Stream Restoration Riparian Buffer	FPU	A	1.52	$ 50,160	2016
Spring Ridge Elementary School - Tree Planting	FPU	A	1.05	$ 34,650	2013
Kemptown Elementary School - Urban Forest Buffer	FPU	A	0.17	$ 5,563	2011
Monocacy Elementary School - Urban Forest Buffer	FPU	A	0.19	$ 1,320	2014
Mountain Village HOA - Urban Forest Buffer	FPU	A	1.22	$ 40,260	2014
Urbana Elementary School - Urban Forest Buffer	FPU	A	0.13	$ 4,290	2011
Valley Elementary School - Tree Planting	FPU	A	0.79	$ 26,070	2009
Utica Park - Urban Forest Buffer	FPU	A	0.29	$ 9,570	2007
Pinecliff Park - Riparian Forest Buffer	FPU	A	0.28	$ 26,070	2012
Crestwood Middle School - Urban Forest Buffer	FPU	A	0.79	$ 26,070	2013
Holly Hills Country Club - Urban Forest Buffer	FPU	A	5.79	$ 191,070	2007
Pinecliff Park - Urban Forest Buffer	FPU	A	0.51	$ 27,000	2010
4338 Prices Distillery Rd	STRE	A	0.27	$ 4,050	2015
Bill Moxley Road Site 9	STRE	A	1.98	$ 29,700	2018
FR Highway Operations-Horine Road	STRE	A	1.32	$ 19,800	2015
Catholic Church Road	STRE	A	1.26	$ 18,900	2017
FR Highway Operations-Bethel Road	STRE	A	0.89	$ 13,275	2015
FR Highway Operations Oak Hill Road	STRE	A	0.42	$ 6,300	2013
Layman Rd at Blacks Mill Rd	STRE	A	1.47	$ 22,050	2018
Englandtowne Stream Restoration	STRE	A	21.90	$ 633,254	2015
Pleasant View Road Site 11	STRE	A	4.65	$ 69,750	2017
Pleasant View Road Site 2	STRE	A	0.69	$ 10,350	2017
4830 Ijamsville Rd	STRE	A	0.83	$ 12,375	2018
Prices Distillery Road, Site 3	STRE	A	1.23	$ 18,450	2012
Pleasant View Road Site 1	STRE	A	2.07	$ 31,050	2017
FR DPW-Bridge No F-20-04-Lewistown Road	STRE	A	4.44	$ 66,600	2015
FR DPW-Old Frederick Road, Bridge No, 20-02	STRE	A	1.53	$ 22,950	2016
Bethel Road Site 1 Stream Stabilization	STRE	A	1.29	$ 19,350	2018

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	NPDES PROGRAM COST	YEAR
FR CO Highway Operations/Lewistown Rd Site 1-4	STRE	A	1.50	$ 22,500	2018
Fr Co Hwy/Mount Zion Road Site 1-3	STRE	A	7.80	$ 117,000	2018
Elmer Derr - Site 3	STRE	A	0.68	$ 10,125	2013
FR Highway Operations-Hollow Road	STRE	A	0.84	$ 12,600	2014
Prices Distillery Rad, Site 1	STRE	A	1.23	$ 18,450	2012
9013 Geisbert Rd	STRE	A	1.80	$ 27,000	2019
Manor at Holly Hills, Ijamsville Road	STRE	A	4.05	$ 60,750	2015
Prices Distillery Road and Haines intersection, 3A	STRE	A	1.02	$ 15,300	2012
Prices Distillery Road, Site 4	STRE	A	1.35	$ 20,250	2012
South Mountain Rd, 1	STRE	A	2.16	$ 32,400	2012
Black Ankle Road	STRE	A	1.83	$ 27,450	2017
Willow Tree Drive	STRE	A	0.60	$ 9,000	2012
Prices Distillery Road, 1/2 mi N of Rt 75	STRE	A	0.84	$ 12,600	2013
Bill Moxley Road Site Culvert	STRE	A	0.99	$ 14,850	2018
Black Ankel Road Site 2 Culvert	STRE	A	4.20	$ 63,000	2017
Jefferson Valley LLC - Woodbourne Manor, MD 383	STRE	A	0.27	$ 4,050	2016
Elmer Derr Road	STRE	A	4.89	$ 73,350	2012
Park Mills Road and Lily Pons Road	STRE	A	0.82	$ 12,285	2015
Jesse Smith Road	STRE	A	6.45	$ 96,750	2017
Little Tuscarora Creek	STRE	A	45.00	$ 675,000	2015
Trout Unlimited Stream Restoration	STRE	A	27.75	$ 416,250	2013
Ballenger Stream Restoration	STRE	A	18.15	$ 406,986	2007
9129 Baltimore Rd	STRE	A	0.54	$ 8,100	2018
Willow Tree Drive South	STRE	A	1.49	$ 22,275	2012
Yeagertown Road	STRE	A	4.38	$ 65,700	2014
FR Highway Operations-Lander Road, Sites 8 and 9 2013	STRE	A	0.48	$ 7,200	2013
Pleasant View Road Site 12	STRE	A	2.43	$ 36,450	2017
Beaver Dam Creek Stream Restoration	STRE	A	43.50	$ 652,500	2015
Fr Co Hwy/Fishers Hollow Rd	STRE	A	0.60	$ 9,000	2018
9401 Baltimore Rd	STRE	A	1.53	$ 22,950	2018
Penterra Manor Road Site 1	STRE	A	0.57	$ 8,550	2017
Feldspar Road	STRE	A	1.71	$ 25,650	2016
East Mountain Road	STRE	A	0.21	$ 3,150	2013
Bethel Road	STRE	A	4.32	$ 64,800	2015
Pine Cliff Stream Stabilization	STRE	A	30.00	$ 427,657	2011
Fish Hatchery Road	STRE	A	1.89	$ 28,350	2013
FR Highway Operations-Catholic Church Road	STRE	A	0.60	$ 9,000	2013
Prices Distillery Road and Haines intersection, 3B	STRE	A	0.99	$ 14,850	2012
Lenhard Rd 2	STRE	A	1.44	$ 21,600	2015
Saint Marks Road	STRE	A	2.46	$ 36,900	2012
Catholic church Road Site 1	STRE	A	0.39	$ 5,850	2015
FR Highway Operations-North Franklinville Road	STRE	A	4.65	$ 69,750	2013

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	NPDES PROGRAM COST	YEAR
Ramsburg Road	STRE	A	3.39	$ 50,850	2015
OSER - Cooperative Extension Building - WQI - 2 Filterra	MMBR	E	0.29	$ 148,810	2019
OSER - Urbana High School - Bioretentions & Rain Gardens	MMBR	E	2.30	$ 249,069	2008
OSER - Cooperative Extension Building - Microbioretention	MMBR	E	0.07	$ 148,810	2019
OSER - Cooperative Extension Building - WQI - 1 Filterra	MMBR	E	0.30	$ 148,810	2019
OSER - Cooperative Extension Building - Rain Tank 1A/1B	MRWH	E	0.03	$ 148,810	2019
OSER - Cooperative Extension Buiding - Rain Tank 2	MRWH	E	0.02	$ 148,810	2019
OSER - Urbana Community Park - Bioretention	FBIO	S	1.70	$ 11,440	2014
Villages of Urbana, Sec. K - 2, Pond 'J' - Retrofit	PWED	S	11.50	$ 159,016	2019
FC - Englandtowne SWM - Retrofit	PWED	S	11.83	$ 584,645	2017
Villages of Urbana, Village V, Sec. K3, Pond "L" - Retrofit	PWED	S	7.10	$ 159,016	2019
Villages of Urbana, Village I, Pond B - Retrofit	PWED	S	3.83	$ 159,016	2019
Law Enforcement Complex - BMP A - Retrofit	PWED	S	7.40	$ 423,799	2019
Villages of Urbana, Sec. M - 5, Pond 'C' - Retrofit	PWED	S	14.60	$ 159,016	2019
Villages of Urbana, Section M-10, SWM Pond 'R' - Retrofit	PWED	S	16.20	$ 159,016	2019
Tranquility - Retrofit	PWET	S	4.68	$ 429,880	2019
Clearview - Retrofit	PWET	S	5.63	$ 377,764	2019
FR Co Hwy / Baltimore Ro*	OUT	A	0.12	$ 5,400	2018
Bill Moxley Road Site 10*	OUT	A	0.13	$ 5,625	2018
Garfield Road Site 1	OUT	A	0.09	$ 3,938	2018
Manor at Holly Hills LLC	OUT	A	0.21	$ 9,450	2015
FR Highway Operations-Da*	OUT	A	0.48	$ 21,600	2016
Frederick Highway Operat*	OUT	A	0.10	$ 4,275	2018
6021 Holter Road - 1	OUT	A	0.08	$ 3,488	2019
Mt. Zion Road and Jeffer*	OUT	A	0.18	$ 8,213	2017
FR Highway Operations-Br*	OUT	A	0.13	$ 5,625	2013
FR Highway Operations-La*	OUT	A	0.20	$ 9,000	2013
Camelot Court	OUT	A	0.13	$ 5,850	2018
Moser Road Culvert	OUT	A	0.07	$ 3,263	2018
Holter Road-2	OUT	A	0.11	$ 4,838	2019
Reich's Ford Road Site #2	OUT	A	0.08	$ 3,600	2016
Spring Ridge Conservancy*	OUT	A	1.28	$ 57,600	2014
Bartonsville Road at Rei*	OUT	A	0.11	$ 4,725	2018
Bartonsville Road 21x15 *	OUT	A	0.10	$ 4,275	2018
Bill Moxley Road Site 1 *	OUT	A	0.09	$ 4,050	2018
6521 Holter Road	OUT	A	0.14	$ 6,224	2019
Holter Road-4	OUT	A	0.05	$ 2,025	2019
West Park Village, LLC	OUT	A	0.30	$ 13,500	2016

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	NPDES PROGRAM COST	YEAR
Kellerton Knolls	OUT	A	0.14	$ 6,300	2018
PVI, LLC - Ballenger Cre*	OUT	A	0.18	$ 7,875	2013
Holter Road-3	OUT	A	0.10	$ 4,388	2019
FR Highway Operations-So*	OUT	A	0.18	$ 8,100	2016
FR Highway Operations-Ij*	OUT	A	0.15	$ 6,750	2019
Natellie Communities - W*	OUT	A	0.45	$ 20,250	2018
Glade Road Culvert	OUT	A	0.13	$ 5,850	2018
FR Highway Operations-Du*	OUT	A	0.44	$ 19,800	2016
FR Highway Operations-Ra*	OUT	A	0.34	$ 15,300	2015
Apples Church Road	OUT	A	0.09	$ 4,163	2018
FR Highway Operations-Br*	OUT	A	0.26	$ 11,700	2013
FR Co Hwy / Baltimore Ro*	OUT	A	0.06	$ 2,700	2018
FR Highway Operations-Wa*	OUT	A	0.17	$ 7,538	2013
Reich's Ford Road Site #1	OUT	A	0.13	$ 5,850	2016
Bartonsville Road 21x15 *	OUT	A	0.11	$ 4,725	2018
Manor Woods Road	OUT	A	0.10	$ 4,455	2012
FR Highway Operations-Br*	OUT	A	0.17	$ 7,650	2014
Total			**749.17**	**$ 15,705,267**	

APPENDIX 2: PROGRAMMED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

The table below includes actions that are planned and funded which will meet impervious area treatment and pollutant reduction requirements. They include projects with completion dates beyond December 31, 2019

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	COST	YEAR
CRL - (Site 7, ID-8411)	FPU	A	0.33	$12,221	2022
CRL - (Site 7, ID-8411)	FPU	A	2.49	$12,221	2022
CRL-Ame #2	FPU	A	3.96	$158,598	2023
CRL-Lev #4	FPU	A	10.33	$413,219	2023
CRL-Lev #1	FPU	A	6.83	$273,373	2023
CRL-Ame #1	FPU	A	1.02	$40,974	2023
CRL-Lev #3	FPU	A	2.06	$82,412	2023
CRL-Lev #2	FPU	A	1.91	$76,545	2023
CRL - (Site 17, ID-8521)	FPU	A	7.96	$61,892	2022
CRL - (Site 18, ID-8522)	FPU	A	0.81	$263,315	2022
CRL - (Site 17, ID-8521)	FPU	A	3.83	$61,892	2022
CRL - (Site 18, ID-8522)	FPU	A	6.60	$263,315	2022
CRL - (Site 19, ID-8523)	FPU	A	2.31	$91,743	2022
CRL - (Site 17, ID-8521)	FPU	A	2.40	$61,892	2022
CRL-Bit #2	FPU	A	0.72	$28,694	2023
CRL-Red #3	FPU	A	5.16	$206,233	2023
CRL-Amb #1	FPU	A	0.81	$32,486	2023
CRL-Bit #1	FPU	A	2.71	$108,506	2023
CRL-Red #1	FPU	A	2.46	$98,565	2023
CRL-Amb #2	FPU	A	1.12	$44,647	2023
CRL-Red #2	FPU	A	5.08	$203,164	2023
Fountain Rock Nature Center and Park	FPU	A	0.21	$2,911	2022
CRL - (Site 8, ID-8431)	FPU	A	1.01	$40,308	2022
Fountain Rock Nature Center and Park	FPU	A	0.14	$1,940	2022
Waterside Tree Planting	FPU	A	5.38	$0	2017
Fountain Rock Nature Center and Park	FPU	A	0.12	$1,663	2022
Md. Ag. Extenstion Services	FPU	A	0.44	$3,382	2022
CRL - (Site 15, ID-8515)	FPU	A	2.90	$416,293	2022
CRL - (Site 15, ID-8515)	FPU	A	10.48	$416,293	2022
CRL-Stc #1	FPU	A	2.03	$81,319	2023
CRL-Stc #2	FPU	A	1.87	$74,707	2023
CRL-Stc #3	FPU	A	0.99	$39,643	2023
CRL-Stc #4	FPU	A	2.25	$89,859	2023
Robin Meadows	FPU	A	4.17	$47,571	2022
Monocacy River Park behind DUSWM	FPU	A	6.60	$99,436	2022

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	COST	YEAR
Monocacy River Park behind DUSWM	FPU	A	3.98	$39,761	2021
CRL-Kal #2	FPU	A	0.14	$5,479	2023
CRL-Kal #1	FPU	A	1.26	$50,277	2023
CRL-Mel	FPU	A	1.01	$40,387	2023
CRL-Kal #3	FPU	A	0.35	$14,099	2023
Catoctin Creek Nature Center	FPU	A	0.12	$21,464	2021
Catoctin Creek Nature Center	FPU	A	0.92	$21,464	2021
Catoctin Creek Nature Center	FPU	A	2.15	$21,464	2021
Catoctin Creek Nature Center	FPU	A	1.82	$21,464	2021
CRL - (Site 9, ID-8445)	FPU	A	5.74	$230,668	2022
CRL - (Site 1, ID-8255)	FPU	A	0.85	$32,172	2022
Catoctin Creek Nature Center	FPU	A	0.49	$21,464	2021
Catoctin Creek Nature Center	FPU	A	0.55	$7,272	2022
Catoctin Creek Nature Center	FPU	A	1.36	$21,464	2021
CRL-Bry #3	FPU	A	0.47	$18,679	2023
CRL-Bry #2	FPU	A	0.24	$9,548	2023
CRL-Bry #4	FPU	A	0.51	$20,469	2023
CRL-Bry #1	FPU	A	0.25	$10,135	2023
Canal Run HOA	FPU	A	0.09	$3,567	2021
Canal Run HOA	FPU	A	0.21	$3,567	2021
Canal Run HOA	FPU	A	0.10	$3,567	2021
Cloverhill Stream Restoration	STRE	A	20.50	$1,586,885	2022
Pine Cliff Phase 2 Stream Restoration	STRE	A	6.00	$459,820	2022
Sam Hills Estates Stream Restoration	STRE	A	9.80	$865,684	2022
Point of Rocks MS4 Stream Restoration - Phase II	STRE	A	12.07	$4,529,333	2022
McKaig Road Regenerative Stormwater Conveyance	STRE	A	3.40	$269,898	2021
Bar T RSC South	STRE	A	3.50	$30,000	2020
Phase I Ltl Hunting Creek Stream Restoration	STRE	A	2.00	$280,000	2021
Point of Rocks MS4 Stream Restoration - Phase I	STRE	A	41.83	$4,546,941	2020
Bar T RSC North	STRE	A	7.15	$30,000	2021
Bar T Stream Restoration	STRE	A	14.51	$30,000	2020
Animal Services - New Stormwater	FBIO	S	5.20	$263,664	2021
FC - Health Department Dry Pond - Retrofit	FSND	S	4.39	$295,000	2021
FC - TransIT - BMP B - Retrofit	FSND	S	3.13	$160,000	2020
Green Hill Manor - SWM Pond #3 - Retrofit	FSND	S	14.91	$461,815	2021
Waterside Detention Basin - Retrofit	PWED	S	14.38	$522,682	2021
New Market West, SWM Pond No. 2 - Retrofit	PWED	S	20.02	$723,761	2021
New Market West, SWM Pond #1 - Retrofit	PWED	S	17.85	$663,078	2021
The Greens Subdivision - New Stormwater	PWED	S	10.39	$380,141	2021

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	COST	YEAR
Cloverhill III, Section 7, ED Basin - Retrofit	PWED	S	16.83	$648,151	2022
Public Safety Training Facility - Retrofit	PWED	S	24.53	$541,742	2021
Robin's Meadow BMP A - New Stormwater	PWED	S	17.68	$695,542	2021
Samhill Estates Regional SWM Facility - Retrofit	PWED	S	28.41	$863,052	2021
Dudrow Business Park, SWM Pond #3 (Toys-R-Us Facility) - Retrofit	PWED	S	101.43	$2,235,000	2020
Urbana Highlands, Sec. P3 - SWM Pond 'PB' - Retrofit	PWED	S	21.10	$159,016	2020
Urbana Highlands, Sec. P3 - SWM Pond 'PA' - Retrofit	PWED	S	16.00	$159,016	2020
Villages of Urbana, Pond 'N' - Retrofit	PWED	S	6.15	$159,016	2020
Urbana Highlands, Sec. P4 - SWM Pond 'PC' - Retrofit	PWED	S	4.80	$159,016	2020
Villages of Urbana, Section K4, Pond 'FF' - Retrofit	PWED	S	2.69	$159,016	2020
Villages of Urbana, SWM Pond A1 - Retrofit	PWED	S	4.50	$159,016	2020
Villages of Urbana, Village I, Pond G - Retrofit	PWED	S	5.03	$159,016	2020
Villages of Urbana, SWM Pond 'S' - Retrofit	PWED	S	1.99	$159,016	2020
Green Hill Manor, Pond #1 - Retrofit	PWED	S	11.75	$1,000,450	2021
Villages of Urbana, Sec. M-8, Pond M1 - Retrofit	PWED	S	11.54	$159,016	2020
Villages of Urbana, Village 1, Pond F - Retrofit	PWED	S	4.69	$159,016	2020
The Legends - Retrofit	PWED	S	10.42	$391,914	2021
Cambridge Farms, SWM Pond No. 1 - Retrofit	PWED	S	7.54	$286,356	2021
Jefferson Court, Section 2 - WQ Pond - Retrofit	PWED	S	3.63	$143,047	2021
The Vistas at Springdale HOA - Retrofit	PWED	S	9.10	$343,533	2021
Holy Family Catholic Community Worship Center - Retrofit	PWED	S	2.07	$85,870	2021
Cambridge Farms, SWM Pond No. 2 - Retrofit	PWED	S	24.19	$896,612	2021
Briercrest Apartments - Retrofit	PWED	S	2.23	$91,734	2021
Jefferson Junction Shopping Center - ED Pond - Retrofit	PWED	S	1.90	$245,568	2020
Roundtree - Section 2 ED Pond - Retrofit	PWED	S	12.53	$847,110	2020
Copperfield SWM Pond - Retrofit	PWED	S	6.78	$245,658	2021
Stanford Industrial, Sec. 3, Pond "B" - Retrofit	PWED	S	9.30	$350,864	2021
Stanford Industrial Park, Sec. 3, Pond "A" - Retrofit	PWED	S	6.50	$248,238	2021
FC - Highway Ops - SWM4 (Highway Shop) Retrofit	PWET	S	6.69	$460,912	2020
Glade Manor - Pond #1 - Retrofit	PWET	S	12.71	$732,383	2021
Builders Supply & Lumber (Evergreen Woodworks) - Retrofit	PWET	S	11.60	$435,163	2021
Green Hill Manor - SWM Pond #2 - Retrofit	PWET	S	20.38	$1,375,705	2020
Springdale Detention Pond - Retrofit	PWET	S	7.99	$302,849	2021

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	COST	YEAR
Fountaindale South - Shallow Marsh Basin - Retrofit	PWET	S	18.17	$1,739,652	2020
Potomac Station Regional Retention Pond - Point of Rocks Retrofit	PWET	S	18.71	$891,292	2022
Total Programmed			**814.68**	**$38,316,922**	

APPENDIX 3: IDENTIFIED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

The table below includes actions that are not yet funded but which have been identified through watershed plans or other studies, and which can help meet impervious area restoration and pollutant load reduction requirements.

BMP_DESCRIPTION	BMP TYPE	BMP CLASS	IMP ACRES	COST	YEAR
Rose Hill Manor Stream Restoration - CARR-2019-STRE-0025	STRE	A	11.99	$681,711	2022
Little Hunting Project 2 (FD22)	STRE	A	9.40	$558,114	2022
BALL-2019-SPSC-1103 - Ballenger Creek Trail New BMP	STRE	A	6.90	$232,394	2022
LIPI-2018-STRE-0001 - 11833 Beaver Dam Rd	STRE	A	42.98	$2,492,983	2024
	STRE	A	8.00	$604,760	2023
LIPI-2018-STRE-0008 - 12601 and 21757 Keymar Rd	STRE	A	24.67	$1,452,243	2022
Stream Restoration Upstream of NPDES 752 C	STRE	A	2.50	$147,100	2022
Stream Restoration Upstream of NPDES 752 A	STRE	A	9.50	$549,980	2022
Stream Restoration Upstream of NPDES 752 B	STRE	A	9.00	$521,560	2022
CATO-2018-STRE-0001 -	STRE	A	43.69	$2,533,340	2025
Little Hunting Creek Project 4 FD23 & FD24	STRE	A	7.00	$534,790	2022
Rose Hill Manor Maintenance BMP - CARR-2019-MSWG-1101	MSWG	E	0.30	$41,985	2021
Cloverhill New Stormwater #1	FBIO	S	18.50	$330,000	2021
Cloverhill New Stormwater #2	FBIO	S	9.25	$165,000	2022
Senior Center New BMP #1 - CARR-2019-FBIO-1093	FBIO	S	0.20	$25,359	2021
Senior Center New BMP #2 - CARR-2019-FBIO-1094	FBIO	S	0.18	$147,286	2021
Spring Ridge - SWM Pond #10 - Retrofit	PWED	S	17.73	$732,686	2023
Spring Ridge - WQ Basin "E" - Retrofit	PWED	S	21.77	$898,502	2024
Spring Ridge - SWM Pond #9 - Retrofit	PWED	S	13.05	$540,694	2024
Spring Ridge - SWM Pond #8 - Retrofit	PWED	S	25.51	$919,493	2021
Windsor Knolls Middle School - Retrofit	PWED	S	13.60	$67,005	2021
Sheppard Pratt, SWM Pond #2 - Retrofit	PWED	S	1.57	$57,543	2021
Sheppard Pratt, SWM Pond #1 - Retrofit	PWED	S	2.25	$82,467	2021
Total Identified			**299.54**	**$14,316,994**	

APPENDIX 4: POTENTIAL PROJECTS AND COSTS

	Number of Projects per TMDL Watershed					
BMP Type	Catoctin Creek	DoublePipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total No. of Projects
Bioretention			9			9.00
Bioswale			2			2.00
Filters						0.00
Grass Channel						0.00
Infiltration						0.00
Wet Pond Retrofit	8		30		4	42.00
Wetland						0.00
Streams (LF)	12.00	0.50	62.00		7.80	82.30
Tree Planting						0.00
Riparian Buffer	5.00	3.25	30.00		7.00	45.25
TOTAL						**180.55**

	Cost per TMDL Watershed					
BMP Type	Catoctin Creek	Double Pipe Creek	Lower Monocacy	Potomac River Mo County	Upper Monocacy	Total Cost by BMP Type
Bioretention	$0	$0	$11,503,080	$0	$0	$11,503,080
Bioswale	$0	$0	$2,556,240	$0	$0	$2,556,240
Filters	$0	$0	$0	$0	$0	$0
Grass Channel	$0	$0	$0	$0	$0	$0
Infiltration	$0	$0	$0	$0	$0	$0
Wet Pond Retrofit	$5,986,400	$0	$22,449,000	$0	$2,993,200	$31,428,600
Wetland	$0	$0	$0	$0	$0	$0
Streams (LF)	$10,410,000	$433,750	$53,785,000	$0	$6,766,500	$71,395,250
Tree Planting	$0	$0	$0	$0	$0	$0
Riparian Buffer	$441,275	$286,829	$2,647,650	$0	$617,785	$3,993,539
TOTAL	**$16,837,675**	**$720,579**	**$92,940,970**	**$0**	**$10,377,485**	**$120,876,709**

APPENDIX 5: MANAGEMENT PRACTICES

STORMWATER BMPS

Many stormwater BMPs address both water quantity and quality, however, some BMPs are more effective at reducing particular pollutants than others. The stormwater practices listed below keep the focus on "green technology" to reduce the impacts of stormwater runoff from impervious surfaces. These BMPs were selected specifically for three reasons: 1) effectiveness for water quality improvement, 2) willingness among the public to adopt, and 3) implementable in multiple facility types without limitations by zoning or other controls.

These practices are consistent with those currently being implemented by Frederick County as water quality improvement projects. The County has the technical expertise, operational capacity, and system resources in place to site, design, construct and maintain these practices. The practices include the following:

Bioretention — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention.

Bioswales —An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.

Urban Filtering - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.

Infiltration — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.

Wet ponds or wetlands — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.

Stream Restoration - Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.

Urban Tree Plantings - Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting

Impervious Surface Reduction - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are credited as impervious surface reduction.

Permeable Pavement - Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.

Vegetated Open Channels - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.

Dry Detention Ponds – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. Hydrodynamic structures are included in this category. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

Dry Extended Detention Ponds - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.

Along with the standard set of structural BMPs listed above, treatment will also be provided through alternative treatment measures including the following strategies that are performed through the programs listed below:

ALTERNATIVE BMPS

IMPERVIOUS SURFACE DISCONNECTIONS

Frederick County has developed a process to account for existing disconnections of impervious surfaces from both rooftop and non-rooftop sources. The County's method involves GIS analysis and field verification of a percentage of credited sites and follows the disconnection methods outlined in the Maryland Stormwater Design Manual. The methodology for rooftop and non-rooftops disconnects has been reviewed and approved by MDE. Currently the County is accounting for these disconnections as baseline treatment.

Rooftop Runoff disconnection treats runoff of residential downspouts by directing the water to pervious areas with relatively low slope. This slows the water and allows it to be infiltrated into the soil. The main functions of this method are to reduce runoff velocity, decrease erosion, and therefore reduce the amount of pollutants reaching local waterways. Some residential areas built previous to 2000 meet the criteria for the rooftop runoff disconnection credit.

Non-rooftop disconnection credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). Sites that are graded to promote overland vegetative filtering may receive a non-rooftop disconnection credit.

Impervious surfaces located within existing stormwater BMP drainage areas were removed from the analysis so as to not double count the impervious treatment credited.

STREET SWEEPING

Street sweeping is a source control operational program that the County has managed to reduce pollutant loads. The County uses vacuum sweepers and tracks the mass of material collected. According to MDE's guidance document (2014a), mechanical street sweeping credits can be tabulated using a mass loading approach based on the relationship between tons of material physically removed and lbs of pollutant per ton of material. Rates used in the calculations are: TN = 3.5 lbs/ton, TP = 1.4 lbs/ton, and TSS = 420 lbs/ton. Impervious credits are calculated as 0.40 equivalent acres treated per ton of material collected.

SEPTIC SYSTEMS

Loads for septic systems in the WTM are based on a loading rate for system type with attenuation through a number of physical processes as well as a standard rate of decay. The number of septic systems was calculated based on the inverse of properties in the County served by sewer in a GIS exercise. Systems are assumed to be conventional, and can be improved upon in a number of ways:

- Septic repairs fix a failing septic system.
- Septic system education is designed to prevent failures through proper management of systems, including regular septic pumping. Effectiveness is based on awareness and willingness to change. A septic system education program will be created in the current permit cycle in the Programmed scenario to meet these goals. A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television.
- Septic connection retirement to sewer requires the ability to connect a system to a sewer line and are not as common but do occur periodically.

SANITARY SEWER OVERFLOW (SSO) REPAIR AND ABATEMENT

SSO abatement is an ongoing program to eliminate deficiencies in the sanitary sewer system that lead to overflows of sewage into streams, primarily during wet weather. The following activities were reported for the County's Chesapeake Bay Two Year Milestones. They are currently are underway and are anticipated to be carried out more intensely in the future.

- Sewage pump station upgrades
- Televised inspection of sewer lines
- Sewer line cleaning
- Sewer line and manhole replacements
- Inflow and infiltration projects
- Root control projects
- Smoke testing

ELIMINATION OF ILLICIT CONNECTIONS

Frederick County has a program to control household illicit connections to the storm sewer system, some of which may be cross-connections between sanitary and storm sewers, leading to contaminated flow from stormwater outfalls. The County's IDDE Program identifies potential illicit discharges in three ways: (1) through dry weather screenings completed during as-built inspections and/or triennial maintenance inspections, (2) through citizen and/or agency reporting, and (3) during biological stream sampling within 75 meter segments of the stream. More information about these programs is available in the County's NPDES MS4 Annual Reports.

DOMESTIC PET SOURCE ELIMINATION

For public lands owned by the County MDE (MDE Bacteria 2014) advocates using agencies such as the park service and public works to improve and/or maintain services such as trash collection and pet waste disposal. The County is working with these entities and reviewing trash collection to identify any potential improvements. These entities are part of the discussion of how to properly implement the pet waste management program. Specifically, the program should include:

- Installation of pet waste stations in areas identified as high dog-walking spots, such as parks and sidewalks
- Assuring the proper management of pet waste stations (such as the regular emptying of waste and replenishment of biodegradable bags)
- A protocol for trash collection and waste disposal, ideally with an identified leader/coordinator who has input from all parties
- Increasing the amount of signage of leash laws and the presence of rangers in parks to support leash law abidance. Possible signs include (VA DEQ, 2011):
    - Picking up your pet's waste helps keep our water clean
    - Pet waste contains bacteria that damages waterways
    - Removal of pet waste required by an ordinance.
    - Neighbors enjoy NOT having to avoid doggie poop while out walking
    - Location of pet waste stations
    - Period reminders

Pet waste management for private land is based on MDE's guidance that "education programs should inform homeowners about pet waste management on their properties and its effects on local waterways. The plan should indicate which agencies are involved and their specific roles." (MDE Bacteria 2014). The pet waste management program will address homeowner education on proper pet waste management and the damage to stream health caused by pet waste. Frederick County initiated various pet waste surveys to obtain feedback from its residents on the habitats that are found throughout the County. Frederick County is moving forward with the next steps of its pet waste program as well as evaluating viable options such as:

- Working with MDE on its Scoop the Poop program
    - MDE (via personal communication with the County's Office of Sustainability and Environmental Resources) is very interested in working to lower pet waste in the state with the Scoop the Poop program. MDE is interested in our proposed sampling effort and may be able to help with outreach efforts and campaigning. This includes development of graphics, magnets with county-specific mascots, and bone-shaped doggy bag holders which can be attached to a leash.
- Creating a Google Map that shows the locations of pet waste stations in communities (VA DEQ, 2011)

- Identifying agencies/offices, community associations, non-profits, and interested members of the community for assistance in this educational program.

EXPANDED PET WASTE EDUCATION

Swann (1999) conducted a study on pet waste education and determined that to reach the highest percentage of the population possible, education should be based on a variety of media. To encourage pet owners to clean up after their pets, PSAs in newspaper, radio, and television would complement awareness messages being spread on the County's website and its social media accounts. Brochures could also augment the educational effort. In addition to the aware message campaign, the County has the following options:

- Installing pet waste stations in residential areas. Pet waste stations should be located in areas that most likely have a high traffic of pet walkers; this specifically includes high density residential areas as identified with GIS land use maps;
- Appointing a Lead Coordinator who will be responsible for pet waste station and biodegradable bag orders, assembly and installation of stations, station maintenance, and outreach (VA DEQ, 2011)

Addressing pet waste is crucial in order for total bacteria counts to lower in the County's waterways. Therefore it is best for the County to use all of the above measures in a concentrated effort that includes the County, park workers, police, schools, any interested non-governmental associations, and volunteers. By using all outreach methods available, we can assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency (VADEQ 2013).

SILT FENCES

When a vegetated buffer is not possible, silt fences can be installed. Locations for silt fences are identified by pin-pointing sources of erosion in watersheds and intersecting those locations with impermeable areas. Although not as efficient as riparian buffers, silt fences lower the rate of *E. coli* entering water bodies and prevent high peaks in *E. coli* counts after storm events (EPA Office of Water, 2012). While Erosion and Sediment Control may not appear to be related to *E. coli* loads in waters, the reasoning behind this is scientifically supported. Erosion and sediment control do factor into water bacteria counts, since erosion into water sources can bring with it bacteria that otherwise would not have contaminated the source (Pachepsky, Y. A. and Shelton, D. R., 2011).

WILDLIFE SOURCE ELIMINATION

According to MDE in the E. coli TMDL for Double Pipe Creek, "Neither Maryland nor EPA is proposing the wildlife controls to allow for the attainment of water quality standards, although managing the overpopulation of wildlife remains an option for state and local stakeholders" (MDE DP 2009); however the SW-WLAs include wildlife sources and are impossible to meet without wildlife management. In its guidance for bacteria TMDLs (MDE Bacteria 2014), MDE states that:

> *The plan should address vector control (i.e., limiting animal populations that transmit disease pathogens) associated with garbage (rats), animal control issues like raccoons, resident geese populations, and where appropriate the management of deer populations. For instance, poor trash handling (i.e., not putting trash bags in cans, etc.) often attracts wildlife (e.g., rats, raccoons, and deer) and encourages these animals to*

> *stay permanently. This results in unintended population explosions in the urban/developed sector.*

Deer are severely overpopulated due to a loss of natural predators, and cause multiple environmental problems to include the loss of plant understory and fecal matter contamination. Though the TMDL focuses primarily on human sources, deer feces was confirmed to be the source of an *E. coli* outbreak in strawberries in Oregon in 2011. *E. coli* in deer feces can persist in the environment. A study by Andrey Guber et al (2014) showed an increase of bacteria growth of 1.5-3 orders of magnitude within the first 4-8 days of deer droppings, and a rate of die-off which still showed active populations 32 days later. Other studies involving leaf splash of fecal material have shown survival up to 177 days. Guber et al. found that deer pellets have an erodibility similar to cow manure disks, which are easily eroded by rain. Substantial studies exist showing the transport of bacteria from cow manure, so the results may be extrapolable. Deer produce an average of 15 pounds manure per 1000 pounds of animal mass per day according to *Population Density Estimates and Fecal Production Rates* by Lucas Gregory. MDE cited 5.00E+08 counts per deer per day in its TMDL for Shellfish in the Lower Patuxent (MDE PAX 2004) using USEPA (2000). That amounts to 182.5 billion CFUs per year. The load to the stream would be affected by transport processes on the surface.

In Frederick County, the Doe Harvest Challenge, run by Farmers and Hunters Feeding the Hungry (FHFH), helps to control deer populations. This is an annual competition. While the program is aimed at feeding the hungry, decreasing crop damage, and keeping deer off of roads, this also lowers wildlife sources of fecal bacteria. Participation is free and unlimited, and hunters receive a Doe Harvest Challenge card for each donated doe. In 2012, this resulted in 3,205 donated deer which resulted in 600,000+ meals in food banks, soup kitchens, and churches in the State of Maryland (Frederick County News Release, 2013).

Throughout the year, two Frederick County butchers, Clint's Cuts and Shuff's Meat Market, participate in FHFH, which is a nonprofit that provides venison to the hungry (MarylandBucks.com). Legally harvested deer can be donated for free at any FHFH donation centers, although meat must be clean, field-dressed deer weighing more than 70 lbs (The Gazette 2009). Future plans could attempt to quantify the MPN in deer feces in order to estimate the benefit of this program on *E. coli* removal.

BMPS FOR FUTURE CONSIDERATION

One element of Adaptive Management is to track emerging practices in pollutant treatment technology. The Chesapeake Bay Program has a formal procedure for this through the Water Quality Goal Implementation Team (WQGIT), which will convene an Expert Panel to review possible new treatment. Frederick County is also tracking potential new programs and practices. A short summary of BMPs which may be considered for future restoration plan updates is discussed below. These BMPs address one or more of the pollutants for which TMDLs have been approved.

Potential BMP	Priority	Nitrogen	Phosphorus	Sediment	Bacteria
Algal Flow-way Technologies	High	x	x	x	
Stream Stabilization Research	High				x
Septic System Authority	Medium	x			x
Hobby Livestock Fencing	Medium		x	x	x

Potential BMP	Priority	Nitrogen	Phosphorus	Sediment	Bacteria
Expanded Cover Crops	Medium	x	x	x	x
Transient Human Populations	Low				x
Canada Goose Abatement	Medium				x
Protecting Natural Predators of *E. Coli*	Low				x

ALGAL FLOW-WAY TECHNOLOGIES

The WQGIT approved the use of Algal Flow-way Technologies (AFT) for nutrient and sediment reductions for both tidal and non-tidal waters. AFTs are gently inclined systems where water to be treated is pumped on to a raceway or screen and allowed to flow down gradient to an outlet. Algae colonize the raceway and take up nutrients from the source water. Periodically, the algae are harvested and removed for either landfilling or reuse for biofuels, compost, soil amendments, or animal feed and the nutrients are removed from the waterbody.

Nutrient credit is determined through sampling and monitoring the mass and concentrations in the harvested algae. MDE (2014) provided guidance for converting pollutant reductions to impervious acre restoration credit. In future restoration plans, Frederick County could investigate sites where installation would be feasible.

STREAM STABILIZATION RESEARCH

E. coli is found in stormwater, and is associated with erosion from land uses because "particulate matter (PM) in runoff serves as a substrate and generates a shielding mechanism for these organisms" (Dickenson 2012). Perhaps more important than the load coming from the land surface, during storm events the near-bank floodplain, streambank, and stream bottom are significant sources of *E. coli* attached to sediment. The WTM as modeled in this plan does not provide a bacteria reduction credit from stream restoration or near-bank sediment management; however, if loads from these sources can be defined through research, the model can be modified to quantify loads and reductions from reduced stream erosion. A growing body of research shows the importance of stream stabilization as an important tool for *E. coli* reduction in streams impacted by stormwater. For example:

- Byappanahalli et al. (2012) notes that "enterococci may be present in high densities in the absence of obvious fecal sources and that environmental reservoirs of these FIB [fecal indicator bacteria] are important sources and sinks, with the potential to impact water quality". Byappanahalli et al. (2003) found that "median *E. coli* counts were highest in stream sediments, followed by bank sediments, sediments along spring margins, stream water, and isolated pools. This study found "significant correlations between *E. coli* numbers in stream water and stream sediment, submerged sediment and margin, and margin and 1 m from shore" in a small coastal stream in Michigan. The study concluded that *E. coli* in riparian sediment can be both a source and sink of chronically high levels of the bacteria seen in the water column.
- Davies et. al. (2015) found that *E. coli* can be persistent when attached to wet sediment, even to TSS in the water column. They conducted an experiment to look at bacteria survival over time and determined that "throughout the duration of the experiment (68 days), the same proportion of *E. coli* organisms remained culturable, suggesting that sediment provides a favorable, nonstarvation environment for the bacteria."

- *E. coli* is preferentially transported in the water column by specific suspended sediment particle sizes; therefore, modeling tools that address TSS may be able to be modified to address *E.coli* fate and transport. (Qian 2016)

BMPs which serve to prevent the loss of sediment from various sources including near bank floodplains, stream banks, and stream bottoms will further protect sediment-bound *E.coli* from entering the water column. In personal communication with Dr. Byappanahalli by email, he suggested that populations are not homogenous in the landscape, which makes prediction of reduction from bank controls extremely challenging.

SEPTIC SYSTEM AUTHORITY

Preventing residential systems from failing is a key prevention strategy. There are several approaches to this, with different levels of cost and effectiveness. Current and future programs consist of outreach and education, and upgrade of failing systems through the Bay Restoration Fund. Establishing an authority similar to a wastewater authority could provide additional financial resources to upgrade or restore failed systems or connect them to the WWTP. This would remove the financial burden from the system owner and increase the likelihood of achieving 100% functional systems.

HOBBY LIVESTOCK FENCING

Reductions of bacteria can be calculated on a per-animal removal basis for livestock. Livestock are not included in the SW-WLAs for any TMDLs; however it is known that residential properties in the watershed often have hobby livestock, to include chickens, horses, and even cattle. An estimate of the number of hobby livestock is not possible, as they are not tracked in the agricultural census; however elimination of these livestock or reduction of their exposure to runoff has a calculable reduction in the WTM. Dairy cattle, for example, are estimated in the WTM to have a 100% exposure to runoff with a bacteria load of 2,000 bn MPN/yr. There is currently no mechanism to address hobby livestock, but the challenges posed by these animals due to overgrazing/bank trampling and stormwater exposure to fecal material should be considered.

EXPANDED COVER CROPS

There is literature supporting the use of crops and vegetative strips to lower the total counts of fecal coliform in nearby waterways. R.A. Young et al. (1979) quantified the effectiveness of vegetative (crop) buffer strips in controlling pollution from feedlot runoff on a 4% slope. Overall runoff was reduced by 67% by crop buffer strips, and an overall reduction in coliform organisms also occurred. Crop buffer strips lowered the total solids transported by 79%, which would also reduce the number of solids that fecal coliform can bind to and use to reach water bodies. Larsen et al (1994) quantified the reduction in fecal coliform transport from manure to the edge of plots at 83% with the addition of 2 foot-long grass sod filter strips. Bacterial transport was not significantly changed by the rain intensities tested.

The County could institute a program of installing and maintaining narrow filter strips in areas where practices that require more space are not feasible. This could be especially impactful in rural areas with hobby farms, since farming conditions were used in Larsen et al. (1994) The County could develop an educational program aimed at rural areas and areas known to have hobby farms, or an incentive program for private residences to develop and maintain narrow filter strips may be pursued. This intriguing potential future scenario would include identifying total number of acres of crops and sod strips being used for this purpose, and an 83% reduction rate for *E. coli* could be used.

TRANSIENT HUMAN POPULATIONS

MDE recommends jurisdictions to address areas that have frequent homeless population visits and public areas without sanitary facilities. MDE (MDE Bacteria 2014) prescribes working with non-governmental organizations, the health department, police, and schools to develop surveys that can be part of an educational outreach program; however the WTM does not take into account educational outreach on health concerns of bacteria in regards to public areas and the homeless.

A comprehensive human source control educational program could include many interested parties working in concert to increase public knowledge of human waste problems in the County. Surveys on areas that are known to be frequented by the homeless could be given out to professionals who have this information, including the police department, health department, and schools. After identifying areas of high traffic, the installation of public restrooms, portable toilets, and/or outreach material on human waste issues could be implemented in identified areas of concern. This would be in conjunction with a County-wide public educational program which should be multimedia based. The County may use television, radio and newspaper public service announcements (PSAs), pamphlets in local stores that volunteer to participate, and County web-pages and social media accounts to ensure the maximum possible percentage of public members are reached. The ability to execute such a program at the current time is low.

CANADA GOOSE ABATEMENT

MDE's bacteria TMDL guidance (MDE Bacterial 2014) states that:

> *poorly vegetated or poorly maintained stormwater management ponds often attract resident geese populations. These factors lead to an increase in bacterial pollution entering nearby waterways. Even though the direct control of these sources does not necessarily fall under the purview of the MS4, bacteria from these sources is transported through the MS4 stormwater collection system to receiving waterbodies.*

Since non-migratory Canada goose (*Branta Canadensis*) populations often return to nesting areas or relocate nearby unless moved at least 200 miles away (French and Parkhurst 2009), techniques that remove significant numbers of geese or prevent them from entering a specific area that is crucial to water conservation should be focused on. The County could start with a list of techniques and identify which ones work best. From French and Parkhurst (2009), unless otherwise noted, these include:

- Husbandry controls
  - Planting species that are less palatable to geese, such as periwinkle, myrtle, pachysandra, English ivy, hosta (plantain lily), and ground junipers
  - Prohibit supplemental feeding of geese, as this promotes continuous congregations of geese in the feeding area
- Non-Lethal Methods
  - Visually frightening devices that resemble scarecrows, owl effigies, or rubber snakes
  - Poles covered with mylar reflective tape, which captures sunlight glare and scares off geese
- Lethal Methods
  - Recreational hunting
  - Addling eggs

- Oiling or puncturing eggs
- Capture
  - During summer molt, when geese are flightless, geese may be rounded up and captured
    - This is a promising practice not only because the geese are flightless but since most complaints about geese occur in spring and summer (Cooper 1998)
    - Temporary barriers such as fences made of wood, wire, rope, or bird-scare tape can be used to enclose and entrap flightless geese
    - Other programs have had success in capturing geese for processing and human consumption (Cooper 1998)

Multiple methods may prove to be useful components of a full goose removal/control program. Quantifying the effects of a goose removal program could be based on each adult goose producing up to 1.5 lbs (680.4g) of fecal matter per day (French and Parkhurst, 2009). According to Alderisio and DeLuca (1999), Canada Goose feces contains average concentration of fecal coliform bacteria per gram of 1.53×10^4; furthermore, “fecal sample weights collected from 171 geese ranged from 0.44 to 25.4 g, with a mean of 8.35 g per goose fecal sample.” The number of CFU per goose per year is estimated to be: 680.4g/25.4g * 1.53×10^4 *365, or 149,544,244.

In addition, public education in the form of signs and brochures at parks and areas of recreation would help strengthen community understanding of wildlife waste and the problems it creates for County waterways. The public should be aware of the program’s goals (the improvement of water quality and therefore water ecosystems via reduction of wildlife waste sources). The public should also know this Plan does not call for the removal of the entire Canada goose population. Canada goose removal is of lower priority because the coliform source is less concerning than human sources, and because the level of effort required for bacteria removal is not the most efficient.

Natural Predators of E.coli

“Grazing by bacterivorous protozoa, bacteriophage infection followed by virus-mediated lysis, and predation by some bacteria are among the biotic effects that control the abundance of prokaryotic organisms in the environment. … Bacteriophage infection affects a much wider range of bacteria, and viral infection was suggested to be a mechanism responsible for the elimination of up to 50% of autochthonous bacteria from aquatic habitats …Some estimates suggest that protozoan grazing is responsible for up to 90% of the overall mortality of both autochthonous and allochthonous microorganisms from freshwater and marine environments (Byappanahalli et. al.

PROTECTING NATURAL PREDATORS OF E. COLI

The persistence of *E. coli* bacteria in wetted sediments may be attributable in part to an upset in natural predation of these bacteria due to the introduction of agricultural chemicals. Staley et al (2014) inhibited natural predation of *E. coli* using several agricultural chemicals to “isolate the effects of predation or competition on survival of allochthonous bacteria. The result of the experiment was that “each treatment increased the survival of Fecal Indicator Bacteria (FIB) and pathogens. Chlorothalonil's effect was similar to that of cycloheximide, significantly reducing protozoan densities and elevating densities of FIB and pathogens relative to the control. Atrazine treatment did not affect protozoan densities, but, through an effect on competition, resulted in significantly greater densities of En. faecalis and *E. coli* O157:H7. Hence, by reducing predaceous protozoa and bacterial competitors that facilitate purifying water bodies of FIBs and human pathogens, chlorothalonil and atrazine indirectly diminished an ecosystem service of fresh water.” In watersheds with combined stormwater and agriculture, decreasing the use of certain agricultural chemicals could lead to reduced bacteria.

BMP EFFECTIVENESS

In order to model load reductions from existing and proposed treatment, currently approved BMPs are assigned a removal rate in percent. The modeling performed for the restoration plan with the geodatabase script uses the most recent guidance from MDE 2014, which bases pollutant removal on two parameters: The amount of rainfall treated per impervious acre (P_E), and the type of BMP: Runoff Reduction (RR) or Stormwater Treatment (ST). Baseline and Completed BMPs P_E for **Baseline** and **Completed** projects is based on data from as-built surveys, design calculations, or other methods. P_E for **Programmed**, **Identified**, and **Potential:** BMPs is assumed to be 1.0.

Removal rate calculations use the curves developed by the Chesapeake Bay Expert Panel on Removal Rates for Urban Stormwater Retrofit Projects, shown below:

TP	RR	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$
	ST	$y = 0.0239x^5 - 0.2058x^4 + 0.7198x^3 - 1.3229x^2 + 1.3414x - 0.0072$
TN	RR	$y = 0.0308x^5 - 0.2562x^4 + 0.8634x^3 - 1.5285x^2 + 1.501x - 0.013$
	ST	$y = 0.0152x^5 - 0.131x^4 + 0.4581x^3 - 0.8418x^2 + 0.8536x - 0.0046$
TSS	RR	$y = 0.0326x^5 - 0.2806x^4 + 0.9816x^3 - 1.8039x^2 + 1.8292x - 0.0098$
	ST	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$

MDE (2014) guidance for determining impervious acre credit for structural, ESD, and alternative BMPs, was used for the calculations in this Plan.

2 = PERMIT				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	1.70	4.70	6.40
Planting Trees on Pervious Urban	FPU	0.00	46.48	46.48
Stream Restoration	STRE	0.00	0.00	4,203.00

3 = PROGRESS				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	1.70	4.70	6.40
Extended Detention Structure, Wet	PWED	62.83	147.15	209.98
Micro-Bioretention	MMBR	0.67	0.25	0.92
Planting Trees on Pervious Urban	FPU	0.00	50.51	50.51
Rainwater Harvesting	MRWH	0.05	0.00	0.05
Retention Pond (Wet Pond)	PWET	7.80	50.40	58.20
Stream Restoration	STRE	0.00	0.00	8,565.80

4 = PROGRAMMED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bio-Swale	MSWB	5.20	0.80	6.00
Extended Detention Structure, Wet	PWED	357.51	1,043.81	1,401.32
Planting Trees on Pervious Urban	FPU	0.00	346.54	346.54
Retention Pond (Wet Pond)	PWET	52.42	201.02	253.44
Sand Filter	FSND	7.24	2.60	9.84
Stream Restoration	STRE	0.00	0.00	6,686.00

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	29.13	28.70	57.83
Extended Detention Structure, Wet	PWED	95.48	162.39	257.87
Grass Swale	MSWG	0.30	0.97	1.27
Stream Restoration	STRE	0.00	0.00	17,563.00

6 - POTENTIAL				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	90.00	180.00	270.00
Bio-Swale	MSWB	20.00	40.00	60.00
Retention Pond (Wet Pond)	PWET	840.00	1,680.00	2,520.00
Stream Restoration	STRE	0.00	0.00	97,760.00
Riparian Buffer		0.00	238.16	238.16

2 = PERMIT					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Bioretention	FBIO	1.70	4.70	6.40	2,133.94
Micro-Bioretention	MMBR	2.30	1.20	3.50	2,257.24
Planting Trees on Pervious Urban	FPU	0.00	41.55	41.55	4,689.63
Stream Restoration	STRE	0.00	0.00	2,720.00	122,400.00

3 = PROGRESS					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Bioretention	FBIO	1.70	4.70	6.40	2,133.94
Extended Detention Structure, Wet	PWED	62.83	147.15	209.98	79,153.57
Micro-Bioretention	MMBR	2.97	1.45	4.42	3,058.95
Planting Trees on Pervious Urban	FPU	0.00	41.55	41.55	4,689.63
Rainwater Harvesting	MRWH	0.05	0.00	0.05	58.34
Retention Pond (Wet Pond)	PWET	7.80	50.40	58.20	15,502.06
Stream Restoration	STRE	0.00	0.00	3,357.80	151,101.00

4 = PROGRAMMED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Bio-Swale	MSWB	5.20	0.80	6.00	5,627.15
Extended Detention Structure, Wet	PWED	216.84	395.93	612.77	272,649.78
Planting Trees on Pervious Urban	FPU	0.00	93.96	93.96	11,467.93
Retention Pond (Wet Pond)	PWET	25.55	76.61	102.16	35,433.43
Sand Filter	FSND	7.24	2.60	9.84	8,358.49
Stream Restoration	STRE	0.00	0.00	4,436.00	199,620.00

5 = IDENTIFIED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Bioretention	FBIO	1.38	0.95	2.33	1,616.95
Extended Detention Structure, Wet	PWED	13.60	13.60	27.20	13,749.96
Grass Swale	MSWG	0.30	0.97	1.27	513.78
Stream Restoration	STRE	0.00	0.00	1,889.00	85,005.00

6 = POTENTIAL					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Bioretention	FBIO	90.00	180.00	270.00	83,437.75
Bioswale	ODSW	20.00	40.00	60.00	18,541.72
Retention Pond (Wet Pond)	PWET	600.00	1,200.00	1,800.00	524,465.84
Stream Restoration	STRE	0.00	0.00	74,400.00	3,348,000.00
Riparian Buffer		0.00	157.89	157.89	14,411.94

APPENDIX 8: LOWER MONOCACY PHOSPHORUS SCENARIOS

2 = PERMIT					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bioretention	FBIO	1.70	4.70	6.40	4.17
Planting Trees on Pervious Urban	FPU	0.00	44.90	44.90	19.77
Stream Restoration	STRE	0.00	0.00	2,396.00	162.93

3 = PROGRESS					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bioretention	FBIO	1.70	4.70	6.40	4.17
Extended Detention Structure, Wet	PWED	62.83	147.15	209.98	150.93
Micro-Bioretention	MMBR	0.67	0.25	0.92	1.45
Planting Trees on Pervious Urban	FPU	0.00	44.90	44.90	19.77
Rainwater Harvesting	MRWH	0.05	0.00	0.05	0.10
Retention Pond (Wet Pond)	PWET	7.80	50.40	58.20	31.72
Stream Restoration	STRE	0.00	0.00	3,303.80	224.66

4 = PROGRAMMED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bio-Swale	MSWB	5.20	0.80	6.00	8.48
Extended Detention Structure, Wet	PWED	263.37	590.24	853.61	655.28
Planting Trees on Pervious Urban	FPU	0.00	225.63	225.63	99.34
Retention Pond (Wet Pond)	PWET	25.55	76.61	102.16	57.23
Sand Filter	FSND	7.24	2.60	9.84	12.70
Stream Restoration	STRE	0.00	0.00	4,436.00	301.65

5 = IDENTIFIED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bioretention	FBIO	1.38	0.95	2.33	2.48
Extended Detention Structure, Wet	PWED	91.66	157.23	248.89	194.48
Grass Swale	MSWG	0.30	0.97	1.27	0.99
Stream Restoration	STRE	0.00	0.00	2,689.00	182.85

6 - POTENTIAL					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bioretention	FBIO	90.00	180.00	270.00	177.77
Bioswale	ODSW	20.00	40.00	60.00	39.51
Retention Pond (Wet Pond)	PWET	600.00	1,200.00	1,800.00	933.75
Stream Restoration	STRE	0.00	0.00	74,400.00	5,059.20
Riparian Buffer		0.00	157.89	157.89	52.51

APPENDIX 9: UPPER MONOCACY SEDIMENT SCENARIOS

2 = PERMIT					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Planting Trees on Pervious Urban	FPU	0.00	1.27	1.27	219.17
Stream Restoration	STRE	0.00	0.00	1,591.50	71,617.50

3 = PROGRESS					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Planting Trees on Pervious Urban	FPU	0.00	1.27	1.27	219.17
Stream Restoration	STRE	0.00	0.00	3,411.50	153,517.50

4 = PROGRAMMED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Extended Detention Structure, Wet	PWED	16.83	73.28	90.11	39,619.38
Planting Trees on Pervious Urban	FPU	0.00	69.41	69.41	11,747.73
Stream Restoration	STRE	0.00	0.00	2,250.00	101,250.00

5 = IDENTIFIED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Bioretention	FBIO	27.75	27.75	55.50	43,067.88
Stream Restoration	STRE	0.00	0.00	1,640.00	73,800.00

6-POTENTIAL					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Retention Pond (Wet Pond)	PWET	80.00	160.00	240.00	96,447.92
Stream Restoration	STRE	0.00	0.00	9,360.00	421,200.00
Riparian Buffer		0.00	36.84	36.84	4,630.11

2 = PERMIT					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Planting Trees on Pervious Urban	FPU	0.00	0.50	0.50	0.22
Stream Restoration	STRE	0.00	0.00	1,591.50	108.22

3 = PROGRESS					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Planting Trees on Pervious Urban	FPU	0.00	0.50	0.50	0.22
Stream Restoration	STRE	0.00	0.00	3,411.50	231.98

4 = PROGRAMMED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Extended Detention Structure, Wet	PWED	16.83	73.28	90.11	51.62
Planting Trees on Pervious Urban	FPU	0.00	69.41	69.41	30.80
Stream Restoration	STRE	0.00	0.00	2,250.00	153.00

5 = IDENTIFIED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Bioretention	FBIO	27.75	27.75	55.50	52.64
Stream Restoration	STRE	0.00	0.00	1,640.00	111.52

6 - POTENTIAL					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Retention Pond (Wet Pond)	PWET	80.00	160.00	240.00	124.15
Stream Restoration	STRE	0.00	0.00	9,360.00	636.48
Riparian Buffer		0.00	36.84	36.84	12.22

APPENDIX 11 CATOCTIN CREEK SEDIMENT SCENARIOS

2 = PERMIT					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Planting Trees on Pervious Urban	FPU	0.00	3.80	3.80	796.55
Stream Restoration	STRE	0.00	0.00	215.50	9,697.50

3 = PROGRESS					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Planting Trees on Pervious Urban	FPU	0.00	3.80	3.80	796.55
Stream Restoration	STRE	0.00	0.00	400.50	18,022.50

4 = PROGRAMMED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Extended Detention Structure, Wet	PWED	77.31	380.29	457.60	208,328.30
Planting Trees on Pervious Urban	FPU	0.00	44.09	44.09	8,534.80
Retention Pond (Wet Pond)	PWET	26.87	124.41	151.28	68,193.80

5 = IDENTIFIED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Extended Detention Structure, Wet	PWED	3.82	5.16	8.98	6,851.52
Stream Restoration	STRE	0.00	0.00	6,469.00	291,105.00

6 - POTENTIAL					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TSS
Retention Pond (Wet Pond)	PWET	160.00	320.00	480.00	160,535.10
Stream Restoration	STRE	0.00	0.00	14,400.00	648,000.00
Riparian Buffer		0.00	26.32	26.32	2,779.43

APPENDIX 12: CATOCTIN CREEK PHOSPHORUS SCENARIOS

2 = PERMIT					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Planting Trees on Pervious Urban	FPU	0.00	1.08	1.08	0.54
Stream Restoration	STRE	0.00	0.00	215.50	14.65

3 = PROGRESS					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Planting Trees on Pervious Urban	FPU	0.00	1.08	1.08	0.54
Stream Restoration	STRE	0.00	0.00	400.50	27.23

4 = PROGRAMMED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Extended Detention Structure, Wet	PWED	77.31	380.29	457.60	275.13
Planting Trees on Pervious Urban	FPU	0.00	44.09	44.09	22.20
Retention Pond (Wet Pond)	PWET	26.87	124.41	151.28	89.62

5 = IDENTIFIED					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Extended Detention Structure, Wet	PWED	3.82	5.16	8.98	8.42
Stream Restoration	STRE	0.00	0.00	6,469.00	439.89

6 - POTENTIAL					
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA	SUM_OF_TP
Retention Pond (Wet Pond)	PWET	160.00	320.00	480.00	184.53
Stream Restoration	STRE	0.00	0.00	14,400.00	979.20
Riparian Buffer		0.00	26.32	26.32	6.62

APPENDIX 13: DOUBLE PIPE CREEK SEDIMENT SCENARIOS

3 = PROGRESS					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Planting Trees on Pervious Urban	FPU	0.00	4.03	4.03	673.81
Stream Restoration	STRE	0.00	0.00	1,450.00	65,250.00

4 = PROGRAMMED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Planting Trees on Pervious Urban	FPU	0.00	7.41	7.41	1,239.32

5 = IDENTIFIED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Stream Restoration	STRE	0.00	0.00	6,765.00	304,425.00

6 - POTENTIAL					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Stream Restoration	STRE	0.00	0.00	600.00	27,000.00
Riparian Buffer		0.00	17.11	17.11	5,080.00

APPENDIX 14: DOUBLE PIPE CREEK PHOSPHORUS SCENARIOS

3 = PROGRESS					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TP**
Planting Trees on Pervious Urban	FPU	0.00	4.03	4.03	1.77
Stream Restoration	STRE	0.00	0.00	1,450.00	98.60

4 = PROGRAMMED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TP**
Planting Trees on Pervious Urban	FPU	0.00	7.41	7.41	3.26

5 = IDENTIFIED					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TP**
Stream Restoration	STRE	0.00	0.00	6,765.00	460.02

6 - POTENTIAL					
BMP_TYPE	**BMP_CODE**	**IMPERVIOUS**	**PERVIOUS**	**TOTAL_AREA**	**SUM_OF_TSS**
Stream Restoration	STRE	0.00	0.00	600.00	40.80
Riparian Buffer		0.00	17.11	17.11	7.53

APPENDIX 15: WTM MODEL ASSUMPTIONS

The WTM requires inputs specific to the watershed. It also contains assumptions which can be modified. Slight modifications were made to the WTM where more specific information was available, and where changes were supported in the literature.

- Primary Sources:
    - Land use and Impervious cover data were based on GIS overlays of the TMDL boundary, the County's MS4 jurisdiction, impervious cover derived from planimetric mapping, and urban land use delineated in MDP's land use/land cover files. To best match the baseline year of 2004, both land use and impervious cover layers as of 2005 were used.
    - The WTM uses a variation of the Simple Method (Schueler, 1987) to calculate loads from urban areas and export coefficients to calculate rural loads. The Simple Method requires an Event Mean Concentration (EMC) to calculate loads. Loads were calculated using EMCs reported in the National Stormwater Quality Database (NSQD) (Pitt et al., 2004). EMCs used in the model are shown below, which also cross-references land use categories from MDP.

MDP Land Use	MDP LU Codes	EMC (MPN/100 mL)
Residential	11,12,13,191,192	8,345
Open Urban	18	7,200
Commercial / Institutional	14,16	4,300
Roadway	80	1,700

    - Annual rainfall: From the Frederick Airport
    - Watershed area: watershed minus municipal areas from GIS
    - Stream miles: stream miles clipped to the watershed boundary in GIS
    - Hydrologic Soil group and depth to groundwater: In GIS from NRCS clipped to watershed boundary minus municipalities
- Secondary Sources
    - Dwelling units:
        - These were calculated in GIS using an overlay of TMDL watersheds, County parcels, residential land use from MDP, and the County MS4 boundary.
        - % Unsewered dwelling units: These were calculated by estimating the number of sewered residential parcels in GIS and subtracting them from the total number of parcels.
    - Septic Systems:
        - % of septic systems <100' to waterway: Calculated by buffering a stream layer by 100 ft and overlaying the result with residential parcel data.
        - Soils: Clay/mixed dominant soils from NRCS
        - System type: assumed to be 100% conventional as this type dominates in Frederick County.
        - Typical separation from groundwater: 5 feet

        - Current septic system management: medium
    - Sanitary Sewer Overflows (SSOs):
        - Default data from WTM was used for number of overflows per mile and quantity of sewage per overflow. Miles of sanitary sewer provided by County agencies.
    - Illicit Connections: Businesses from planning layer
    - Urban channel
        - Method 1 standard assumption of channel erosion
- Existing Management Practices: Serves as baseline and does not change between model runs.
    - Pet waste education: no
    - BMPs: assume zero for existing scenario
    - Riparian Buffers: calculated from forest layer using 35 foot buffer calculation using total area of forest within the buffer
    - Maintenance: .4, no ordinance
- Future Management Practices: Changes for each model run. WTM1 represents **Completed**, WTM2 is **Programmed**, WTM3 is **Identified** and WTM4 is **Potential**.
    - Pet waste education:
        - **Completed:** No
        - **Programmed**, **Identified**, and **Potential:** yes for all scenarios. From Swann (1999), use multiple outreach methods including television, assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency.
    - Riparian buffers: Acres converted to miles at 35 foot buffer.
    - "Urban Downsizing" Forested land uses are added and vacant lots or low density residential lawns are reduced commensurate with the number of acres of forest buffers planted. This is to address the land use change portion of the riparian buffer BMP.
    - Stormwater retrofits: Load reductions for wet ponds, wetlands, and filters were not changed from the number given in the WTM. Hunt et al. (2008) found the bacteria removal efficiency of bioretention practices to be 70%. The manner in which the County implements bioswales fits with the Watershed Treatment Model's definition of a bioretention practice; therefore bioswale was given a 70% reduction as well. Scenarios for the WTM for structural stormwater management retrofits come from the same geodatabase export as the nutrient/sediment models for each watershed.
    - Illicit Connection Removal: 100% of the system is surveyed with varying percents of repairs made. 100% was used for **Potential** treatment.
    - Sanitary Sewer Overflow (SSO) Repair/Abatement: The County has an SSO abatement program and has shown a downward trend of SSOs over time. SSO repair was assumed to be 100% for **Potential** treatment.
    - Septic System Education: A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television. The purpose of the education is to increase the level of routine maintenance and septic pumping to reduce failures.
    - Septic System Repair: Repairs are based on 100% inspection and a repair rate consistent with the number performed by the Health Department for each watershed over a five year period. Septic repairs fix a failing septic system. Repairs were applied to 100% of the systems within the watershed.

- Septic System Retirement: The County has completed seven of these in the past ten years. This information was reported by the Planning Department.

APPENDIX 16: DOUBLE PIPE CREEK *E.COLI* SCENARIOS

STRUCTURAL BMPS

3 = PROGRESS				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Planting Trees on Pervious Urban	FPU	0.00	4.03	4.03
Stream Restoration	STRE	0.00	0.00	1,450.00

4 = PROGRAMMED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Planting Trees on Pervious Urban	FPU	0.00	7.41	7.41

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Stream Restoration	STRE	0.00	0.00	6,765.00

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Stream Restoration	STRE	0.00	0.00	600.00
Riparian Buffer		0.00	17.11	17.11

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	Number	Unit
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	4	systems
Septic System Repair	75	systems
Septic System Upgrade	6	systems
Septic System Retirement		

2 – PROGRAMMED		
BMP Type	**Number**	**Unit**
Pet Waste Education	32	households
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	48	systems
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	11.0	ac
Illicit Connection Removal	50%	remediated
SSO Repairs		
Septic System Education		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	243.30	acres
Illicit Connection Removal	50%	remediated
SSO Repairs		
Septic System Pumping		
Septic System Repair	297	systems
Septic System Upgrade		
Septic System Retirement		

STRUCTURAL BMPS

2 = PERMIT				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	1.70	4.70	6.40
Micro-Bioretention	MMBR	2.30	1.20	3.50
Planting Trees on Pervious Urban	FPU	0.00	66.78	66.78
Stream Restoration	STRE	0.00	0.00	3,001.00

3 = PROGRESS				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	1.70	4.70	6.40
Extended Detention Structure, Wet	PWED	62.83	147.15	209.98
Micro-Bioretention	MMBR	2.97	1.45	4.42
Planting Trees on Pervious Urban	FPU	0.00	66.78	66.78
Rainwater Harvesting	MRWH	0.05	0.00	0.05
Retention Pond (Wet Pond)	PWET	7.80	50.40	58.20
Stream Restoration	STRE	0.00	0.00	3,908.80

4 = PROGRAMMED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bio-Swale	MSWB	5.20	0.80	6.00
Extended Detention Structure, Wet	PWED	263.37	590.24	853.61
Planting Trees on Pervious Urban	FPU	0.00	225.63	225.63
Retention Pond (Wet Pond)	PWET	25.55	76.61	102.16
Sand Filter	FSND	7.24	2.60	9.84
Stream Restoration	STRE	0.00	0.00	4,436.00

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	1.38	0.95	2.33
Extended Detention Structure, Wet	PWED	91.66	157.23	248.89
Grass Swale	MSWG	0.30	0.97	1.27
Stream Restoration	STRE	0.00	0.00	2,689.00

6 - POTENTIAL				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	90.00	180.00	270.00
Bioswale	ODSW	20.00	40.00	60.00
Retention Pond (Wet Pond)	PWET	600.00	1,200.00	1,800.00
Stream Restoration	STRE	0.00	0.00	74,400.00
Riparian Buffer		0.00	157.89	157.89

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	95.8	acres
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	3,400	systems
Septic System Repair	22	systems
Septic System Upgrade	84	systems
Septic System Retirement	6	systems

2 – PROGRAMMED		
BMP Type	**Number**	**Unit**
Pet Waste Education	2,648	households
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	110.0	acres
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	284.8	ac
Illicit Connection Removal	50%	remediated
SSO Repairs	35%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		
Illicit Connection Removal	50%	remediated
SSO Repairs	40%	remediated
Septic System Pumping		
Septic System Repair		systems
Septic System Upgrade		
Septic System Retirement		

APPENDIX 18: UPPER MONOCACY RIVER *E.COLI* SCENARIOS

STRUCTURAL BMPS

2 = PERMIT				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Planting Trees on Pervious Urban	FPU	0.00	1.27	1.27
Stream Restoration	STRE	0.00	0.00	1,591.50

3 = PROGRESS				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Planting Trees on Pervious Urban	FPU	0.00	1.27	1.27
Stream Restoration	STRE	0.00	0.00	3,411.50

4 = PROGRAMMED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Extended Detention Structure, Wet	PWED	16.83	73.28	90.11
Planting Trees on Pervious Urban	FPU	0.00	69.41	69.41
Stream Restoration	STRE	0.00	0.00	2,250.00

5 = IDENTIFIED				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Bioretention	FBIO	27.75	27.75	55.50
Stream Restoration	STRE	0.00	0.00	1,640.00

6 - POTENTIAL				
BMP_TYPE	BMP_CODE	IMPERVIOUS	PERVIOUS	TOTAL_AREA
Retention Pond (Wet Pond)	PWET	80.00	160.00	240.00
Stream Restoration	STRE	0.00	0.00	9,360.00
Riparian Buffer		0.00	36.84	36.84

OPERATIONAL BMPS

1 – COMPLETE		
BMP Type	Number	Unit
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest	87.6	acres
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	1,053	systems
Septic System Repair	32	systems
Septic System Upgrade	84	systems
Septic System Retirement	1	systems

2 – PROGRAMMED		
BMP Type	**Number**	**Unit**
Pet Waste Education	600	households
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		
Illicit Connection Removal		
SSO Repairs		
Septic System Pumping	605	systems
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

3 – IDENTIFIED		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		
Illicit Connection Removal	50%	remediated
SSO Repairs	50%	remediated
Septic System Pumping		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		

4 – POTENTIAL		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Land Use Change to Forest		ac
Illicit Connection Removal	50%	remediated
SSO Repairs	50%	remediated
Septic System Pumpingc1		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement		